JUL 9 1925

RAILWAY CENTENARY NUMBER.

ENGINEERING:

An Illustrated Weekly Journal.

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VOL. CXIX.—No. 3104] LONDON: FRIDAY, JUNE 26, 1925. [Registered at the General Post Office as a Newspaper.] [PRICE ... 1s. BY INLAND POST 1s. 2½d.

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2581

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CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 85.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 2179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
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See half-page Advert. last week and next week. 2781

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 2591

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 2530
See Advertisement last week, page 13.

Spencer-Hopwood & Kirke
PATENT BOILERS *See Page 38, June 19.* 1994
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 2572

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Hammers, Presses, Furnaces,
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Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd.,
Newton Heath Glass Works,
Manchester. Od 9753

For Your Repairs or any
SPECIAL MACHINERY, try
THOMAS HUNT & SONS,
Albion Ironworks,
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CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
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Chief Offices: 129, Trongate, Glasgow. Od 8547
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Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY
and
ENGINEERING WORKS.
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Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Ingot Iron Tubes. 2257
The Scottish Tube Co., Ltd.
HEAD OFFICE: 34, Robertson Street, Glasgow.
See Advertisement, page 33, June 19.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS.
2276

Campbells & Hunter, Ltd.
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Worm Wheels cut up to 13 ft. diam
Bevel and Mitre Wheels planed up to 6 ft. 6 in. diam.
Spur Wheels cut up to 12 ft. 6 in. diam.
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Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS. Od3382
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OIL FUEL APPLIANCES,
Systems
PRESSURE AIR, STEAM
For Boilers of all types.
KHRMODES LIMITED,
35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
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GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
BRICK and CLAYWORKING MACHINERY of all kinds.
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Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising London." —Great Eastern Road, Stratford, E. 15. 1794

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RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 2633

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AND PROPULSION PROBLEMS.
Special designs only.
"Circulation Theory."
Akimoff Propeller Company,
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(Established 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
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MILLWALL, LONDON, E.
GENERAL CONSTRUCTIONAL ENGINEERS. 1216
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETTED STEAM and VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings
AND
Steel Plates.
STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 37. 2584

Peter Brotherhood Ltd.,
PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 2858
See Advertisement, page 51, June 19.

Telegrams: "Epa," London.
Telephone: 7424 Central.
E. P. Alexander & Son.
CHARTERED PATENT AGENTS,
306, High Holborn, London, W.C.1. 585
PATENTS. DESIGNS. TRADE MARKS.

Patents and Trademarks.—
Patent your Inventions, Trademark your goods. Advice, handbook and cons. free.—B. T. KING, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A. and Can.), 146a, Queen Victoria Street, E.C.4. 38 yrs. refs. 'Phone: 682 Central for full information. 1209

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A Large Selection of
New and Second-hand Plant
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BOILERS, ENGINES, PUMPS,
ELECTRICAL AND CONTRACTORS' PLANT MACHINE TOOLS.
Write for Catalogue.
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AND SCREW SLOTTING CUTTERS.
JOSEPH THOMPSON (Sheffield) LTD.,
Townhead Street Engineering Works,
SHEFFIELD. 2677

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ELECTRICAL
INSULATING FABRICS
AND TAPES.
Manufactured solely by—
M. BARR & CO., LTD.,
83, Hutcheson Street, Glasgow.
2021

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ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES } ROWS PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
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High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

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LAND AND MARINE
YARROW BOILERS.
2277

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Walter Somers, Limited,
HALESOWEN. 7116

Matthew Paul & Co., Ltd.,
LEVENFORD WORKS, Dumbarton. 2878
See Full Page Advt., page 56, June 19.

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For Production of SHEET METAL PRESS WORK, also Makers of MINTING & CARTRIDGE PLANTS.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 54, June 19. 8195

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 2735
E. GREENWICH, LONDON, S.E.10 (& at Birmingham)

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED
DARLINGTON. 2702

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MECHANICAL ENGINEERS,
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Undertake SPECIAL MACHINE WORK of any description.
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LATHE WORK up to 10 ft. diameter.
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Branch Office: 4, Albert Square, Manchester.
Regd. Offices: 10, Princes St., Westminster, S.W.1.
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New 300 & 500 B.HP. M.A.N.
STATIONARY DIESEL ENGINES with accessories, as delivered from the makers under Peace Treaty; also Dynamos for same. All spare parts in stock.—RICK-DIESEL OIL ENGINES LTD., 70, Queen Victoria Street, E.C.4. 2527

Petter Oil Engines.
For Paraffin and Crude Oil
Sizes 1½ B.HP. and upwards.
Petters Limited, Yeovil.
Sizes 25 to 500 B.HP.
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See advertisement alternate weeks. 9315

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John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
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Makers of
Evaporating and Distilling Plants.
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Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 2397

The Manchester Steam Users ASSOCIATION.

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Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2701

Crystal Palace School of Practical Engineering. Founded 1872. MECHANICAL AND CIVIL ENGINEERING DIVISIONS.

President: J. W. WILSON, M.I.C.E., M.I.M.E.
Principal: MAURICE WILSON, M.I.C.E.
Assisted by Staff of Lecturers and Instructors.
Thorough up-to-date Practical and Theoretical Instruction. Course completed in 2 years.
Students admitted at beginning of any Term.
Of the Students who have passed through the School, many have obtained appointments as Chief Engineers at home and abroad; and upwards of 1400 are employed in Engineering work in various countries. 2896

University College, SOUTHAMPTON.

The College Offers Excellent Opportunities for training in CIVIL, MECHANICAL and ELECTRICAL ENGINEERING.

Courses are provided in preparation for:—
B.Sc. (Engineering), University of London;
Membership of Professional Institutions;
College Diploma, and Practical Engineering.

The next Session commences on Monday, 5th October. Early application should be made to the REGISTRAR, for "*Hand-book of the Faculty of Engineering*," "*Engineering Scholarships*," and "*Calendar*." J 419

Correspondence Courses for

Inst. Civil Engrs., Inst. Mech., London Univ. Matric., Inter., B.Sc.), Inst. M. & Cy. E., and ALL ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours) Eng. London, Assoc.M.Inst.C.E., Chartered Civil Engineer. M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams., comprising hundreds of successful Students. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 2689

Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 96, St. George's Square, London, S.W.1. G 758

Engineering Salesmanship and SALES MANAGEMENT.—Write for

brochure describing our special Course of Training for posts of unlimited scope in the lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 77, Millgate Building, Manchester. 2863

TENDERS.

COUNTY OF LONDON.

RE-PAVING OF CARRIAGEWAYS.

The London County Council invites

Tenders for the Taking Up

and REMOVAL of the EXISTING PAVING of the CARRIAGEWAY, the making good (where so required) and rendering of the existing concrete foundation, also the repaving with creosoted wood blocks and other incidental works of:—

(A) Part of Northumberland Avenue adjoining the Victoria Embankment; and
(B) Vauxhall Bridge and approaches.

Persons desiring to submit Tenders for either or both of these works may obtain the Specifications, Bills of Quantities, Forms of Tender and Contract, etc., on application to the Chief Engineer of the Council, at the Old County Hall, Spring Gardens, S.W.1, upon payment in each case of the sum of £3. This amount will be returnable only if the Tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the works may be obtained on personal application, and the contract documents may be inspected before payment of the fees.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m., on Monday, 13th July, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX, Clerk of the London County Council. J 415

ADMINISTRATIVE COUNTY OF LONDON.

BEVERLEY BROOK RELIEF CULVERT.

The London County Council invites

Tenders for the Construction

of about 2256 lineal feet of 8 ft. 0 in. × 8 ft. 0 in. CONCRETE CULVERT, from the Beverley Brook, near Priests Bridge, Upper Richmond Road, to the south bank of the River Thames, about 800 lineal feet above Barnes Bridge (Southern Railway—L. & S.W. section), including an inlet weir at the head of the culvert, a flap chamber and outlet apron on the south bank of the River Thames, and the diversion of local sewers. The new works will be situate almost entirely in the Urban District of Barnes, in the County of Surrey.

Persons desiring to submit Tenders, may obtain the Form of Tender and Contract, Specification, Bill of Quantities and Drawings on application to the Chief Engineer of the Council, at the Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £10. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before payment of the fee.

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Twelve Noon, on Tuesday, 21st July, 1925, will be considered.

The Council does not bind itself to accept the lowest or any Tender.

MONTAGU H. COX, Clerk of the London County Council. J 378

DRYDOCKING, ETC., OF R.A.S. "WHITE CROSS."

The METROPOLITAN ASYLUMS BOARD invite

Tenders for Drydocking and

REPAIRING the HULL and FITTINGS of the river ambulance steamer "WHITE CROSS."

Specifications, Conditions of Contract and Form of Tender may be obtained at the Office of the Board, Victoria Embankment, London, E.C.4.

Tenders, addressed as noted on the Form of Tender, must be delivered at the Office of the Board not later than Ten a.m., on Wednesday, 15th July, 1925.—

G. A. POWELL, Clerk to the Board. J 382

TO BUILDERS.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, etc., are prepared to receive

Tenders before Eleven

a.m., on Wednesday, 8th July, 1925, for the INSTALLATION of LOW PRESSURE HOT WATER HEATING SERVICE (forced circulation) and a SUMP PUMP, at Brighton Sorting Office and Telephone Exchange.

Drawings, Specification, a copy of the Conditions and Form of Contract, Bills of Quantities, Forms for Tender, etc., may be obtained from the CONTRACTS BRANCH, H.M. Office of Works, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to The Commissioners of H.M. Works, &c.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. J 400

COUNTY BOROUGH OF BOLTON.

WATERWORKS DEPARTMENT.
PUMPING PLANT—LOWER HEIGHT WELL.

Tenders are Invited for

SUPPLYING, ERECTING and SETTING TO WORK a HEAVY-OIL ENGINE DRIVEN BOREHOLE PUMPING PLANT, having a capacity of 700 gallons per minute from a depth of 365 feet below the intended engine-house floor to a level of about two feet below that floor, and other Plant in connection therewith, at the LOWER HEIGHT WELL, in the township of BELMONT, near BOLTON.

The instructions to persons tendering, and other contract documents, may be seen on application at the Office of Mr. JOHN K. SWALES, M.Inst.C.E., Waterworks Engineer, St. George's Street, Bolton, and copies thereof may be obtained on the deposit of Three Guineas, which will be returned to tenderers who have submitted a *bona-fide* Tender and returned all the documents supplied.

Tenders are to be submitted in accordance with the "Instructions to Persons Tendering," above referred to before Ten a.m., on the 20th July, 1925.

SAMUEL PARKER, Town Clerk.

Town Hall, Bolton.
22nd June, 1825. J 337

COUNTY BOROUGH OF BRIGHTON. WATERWORKS DEPARTMENT.

TO MAINLAYING CONTRACTORS.

The Waterworks Committee are prepared to receive

Tenders from responsible

Contractors for LAYING about 2520 yards of 18 in., and about 1780 yards of 16 in. CAST IRON MAINS in Ditchling Road, Hollingbury Road, Hollingdean Road, Old Lane, and Surrenden Road, Brighton.

Specification, Quantities, and Form of Tender may be obtained, and Drawings inspected, on application to Mr. A. B. CATHCART, M.Inst.C.E., Waterworks Engineer, 12, Bond Street, Brighton, on payment of a deposit of Three Guineas, which will be refunded upon receipt of a *bona fide* Tender, not subsequently withdrawn, and the return of all documents.

Sealed Tenders, endorsed "Tender for laying 18 in. and 16 in. Water Mains," to be delivered at my Office, Town Hall, Brighton, not later than Noon, on Monday, July 6th, 1925.

The lowest or any Tender will not necessarily be accepted, and Tenders will only be considered from responsible Contractors having the necessary experience.

JAS. H. ROTHWELL, Town Clerk.

Town Hall, Brighton.
10th June, 1925. J 308

By Order of the Receiver for Debenture Holders, C. J. Pain, Esq., F.C.A.
MESSRS. CUTTING BROS., PARK WORKS, STAMFORD.

HENRY BUTCHER & CO. Have received instructions to offer

For Sale by Tender, as Going CONCERN,

the Old-established
ELECTRICAL ENGINEERING WORKS MANUFACTURING ELECTRIC MOTORS, GENERATORS, &c.

The Works are in full operation, with orders in hand and with Works and Office Staff which could be retained.

THE PROPERTY is FREEHOLD, having a site area of 4 acres, and comprising Workshops and Foundry with clear FLOOR SPACE of about 34,000 sq. ft. Offices, Yard and Land for extension adjoining the London, Midland & Scottish Railway.

The WORKSHOPS, IRON and BRASS FOUNDRIES are fully equipped with Modern Plant and Machinery.

Included in the assets are
COMPLETE WORKING DRAWINGS and PATTERNS
for Motors and Generators up to 100 Kw., Polishing Lathes, etc.
STOCK, STORES, FURNITURE and all EQUIPMENT.
Together with the GOODWILL of the BUSINESS.

The Works may be inspected between the hours of Ten a.m. and Four p.m. from MONDAY, JUNE 29th, to FRIDAY, JULY 3rd, inclusive.

Tender Forms and full particulars can be obtained from:—

Messrs. HUBBART, DUROSE & PAIN, Chartered Accountants, 18, Low Pavement, Nottingham and 46, Holborn Viaduct, London, E.C.1.
Messrs. HENRY BUTCHER & CO., Engineering Auctioneers, Valuers and Surveyors, 63 and 64, Chancery Lane, London, W.C.2. J 345

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for :—

VACUUM BRAKE FITTINGS for Carriages and Wagons,

Tenders due on the 10th July, 1925.
Tender Forms obtainable from above. J 418

THE SOUTH INDIAN RAILWAY COMPANY LIMITED.

The Directors are prepared to receive

Tenders for the Supply of:—

1. STEEL TYRES for Locomotive Engines and Tenders.
2. LEATHER BELTING, HIDES, etc.
3. MISCELLANEOUS ARTICLES.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Steel Tyres," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 10th July, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 5s. for each copy of Specifications Nos. 1 and 2, and 10s. for each copy of Specification No. 3.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD, Managing Director.

91, Petty France, Westminster, S.W.1.
24th June, 1925. J 423

THE HIGH COMMISSIONER FOR INDIA is prepared to receive

Tenders for the Supply

of:—

1. FOUR STEAM COALING CRANES to lift 1¼ tons at 25 ft. radius.
2. TWIN-SCREW STEAM HOPPER DRAG and CUTTER SUCTION DREDGER, with 30 in. pipe line.
3. COMBINED ROCK-BREAKING VESSEL and DIPPER DREDGE.

Forms of Tender may be obtained from the DIRECTOR-GENERAL, India Store Department, Branch No. 16, Belvedere Road, Lambeth, S.E.1, and Tenders are to be delivered at that Office not later than Two o'clock p.m., on Tuesday, 14th July, 1925, for No. 1, and on Friday, 24th July, 1925, for Nos. 2 and 3. J 417

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

100 OPEN AND 100 COVERED GOODS WAGON UNDERFRAMES AND BODIES (WITHOUT BOGIES AND WHEELS AND AXLES).

Specification and Form of Tender can be obtained at the Company's Offices, 132, Gresham House, Old Broad Street, London, E.C.2, on or after 25th June, 1925.

A fee of 20s. will be charged for the Specification, which is NOT returnable.

Tenders must be submitted not later than Noon, on Thursday, 9th July, 1925.

The Directors do not bind themselves to accept the lowest or any Tender, and reserve to themselves the right of reducing or dividing the order.

By Order of the Board. R. C. VOLKERS, Secretary. J 416

COUNTY BOROUGH OF BRIGHTON.

WATERWORKS DEPARTMENT.

TO PIPE FOUNDERS.

The Waterworks Committee invite

Tenders for the Supply of

about 360 tons of 16 in. diameter Class "C," 240 tons of 18 in. diameter Class "B," and about 320 tons of 16 in. diameter Class "C" CAST IRON PIPES to the British Standard Specification, together with Specials of both diameters, delivered in Brighton.

Specification and Form of Tender may be obtained from the Waterworks Engineer, Mr. A. B. CATHCART, M.Inst.C.E., 12, Bond Street, Brighton, upon payment of a deposit of Two Guineas, which will be refunded upon receipt of a *bona fide* Tender not subsequently withdrawn.

Sealed Tenders, endorsed "Tender for C.I. Pipes," to be delivered at my Office, Town Hall, Brighton, not later than Noon, on Monday, July 6th, 1925.

The Committee do not bind themselves to accept the lowest or any Tender.

JAS. H. ROTHWELL, Town Clerk.

Town Hall, Brighton,
10th June, 1925. J 307

METROPOLITAN WATER BOARD.

SUPPLY OF POSITIVE TYPE WATER METERS.

The Metropolitan Water Board Invite

Tenders for the Supply of

250 ¾ in., 250 ¾ in., 150 1 in., and 100 1½ in. POSITIVE TYPE WATER METERS, to be delivered to the Board's works at Anwell Street, Clerkenwell, E.C. 1.

Forms of Tender may be obtained from the Chief Engineer by personal application (Room 156), or upon forwarding a stamped addressed brief envelope.

Tenders, on the official form, addressed to the "Clerk of the Board," Metropolitan Water Board, 173, Rosebery Avenue, E.C.1, endorsed "Tender for Water Meters," must be delivered at the Offices of the Board not later than Eleven a.m., on Friday, 3rd July, 1925.

The Board do not bind themselves to accept the lowest or any Tender.

C. F. STRINGER, Clerk of the Board.

173, Rosebery Avenue, E.C.1.
23rd June, 1925. J 414

THE ISLINGTON BOROUGH COUNCIL invite

Tenders for the Supply and

ERECTION at their Electricity Station, Eden Grove, Holloway, London, N. 7, of an ELECTRICALLY OPERATED FIFTY-TON LIFTING LOAD OVERHEAD TRAVELLING CRANE, with the necessary steel stanchions, gantry and other structural work. Forms of Tender, Specification and Plans can be obtained on and after the 4th July, 1925, from the Borough Electrical Engineer, 60, Eden Grove, Holloway, N.7. Tenders, endorsed "Tenders for Crane," must be delivered to the undersigned not later than NOON, on MONDAY, the 10th August, 1925.

The Council do not bind themselves to accept the lowest or any Tender.

By order, C. G. E. FLETCHER, Town Clerk.

Municipal Offices, Tyndale Place, Upper Street, London, N. 1.
20th June, 1925. J 381

APPOINTMENTS OPEN.

BRADFORD EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

Applications are Invited for

the APPOINTMENT of LECTURER in the Department of Civil Engineering, Architecture and Building in the College.

A salary up to £575 may be paid to a candidate of suitable qualifications and experience. Candidates should preferably possess a good degree in Civil Engineering and have had practical experience in public works and buildings.

Full particulars of the appointment, and forms of application may be obtained from the Principal of the College, to whom the applications should be returned completed, not later than Wednesday, 8th July, 1925.

N. L. FLEMING, Town Clerk. J 398

HULL EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL COLLEGE.

Principal: T. LUXTON, B.A., B.Sc. (London).

LECTURER IN ELECTRICAL ENGINEERING.

Wanted, to commence duties

on the 1st September next, a LECTURER in Electrical Engineering, with a good Honours Degree in Electrical Engineering. Salary according to Burnham Award, with additional payments on an approved Scale for Evening Classes.

Further particulars may be obtained on receipt of a stamped addressed foolscap envelope.

Applications must be received at these Offices not later than the 1st July.

J. T. RILEY, D.Sc., Director of Education.

Education Offices, Guildhall, Hull.
22nd June, 1925. J 390

BRADFORD EDUCATION COMMITTEE.

TECHNICAL COLLEGE.

Applications are Invited for

APPOINTMENT as HEAD of the DEPARTMENT OF MECHANICAL ENGINEERING in the College.

A salary up to £700 per annum may be paid to a candidate of suitable qualifications and experience.

Full particulars of the appointment, and forms of application, may be obtained from the Principal of the College, to whom applications should be returned completed not later than Friday, 3rd July, 1925.

N. L. FLEMING, Town Clerk. J 317

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

CIVIL ENGINEERING DEPARTMENT.

Applications are Invited from

qualified persons for the APPOINTMENT of RESIDENT ENGINEER on the construction of a Reinforced Concrete Reservoir of about seven million gallons capacity and contingent works at Dudley.

Applicants must be corporate members of the Institution of Civil Engineers, have had considerable experience in reinforced concrete construction, preferably in relation to Waterworks, and be capable of carrying out the tests for cement, as laid down in the latest British Standard Specification for Portland Cement.

A Medical Certificate of fitness will be required.

The Salary will be at the rate of £450 per annum inclusive, and the duration of the appointment eighteen months to two years.

Applications, stating age, and giving details of education, training and experience, accompanied by copies only of three recent testimonials, should be addressed and delivered to the undersigned not later than 6th July, 1925.

FRED. J. DIXON, M.Inst.C.E., Engineer-in-Chief.

Engineer's Office, 26a, Paradise Street, Birmingham. J 348

Executive Engineers

(Three) REQUIRED by the GOVERNMENT of the GOLD COAST for the PUBLIC WORKS DEPARTMENT for a tour of 12 to 18 months' service with possible extension. Salary £480 a year for the first three years of service, then £510, rising to £720 a year by annual increments of £30, and thence rising to £920 a year by annual increments of £40. Free quarters and passages and liberal leave on full salary. Outfit allowance of £60 on first appointment. Candidates, age 25 to 35, should have been trained as Architects or Civil Engineers and be capable of taking entire control of the construction of concrete and other buildings, a knowledge of quantities and measuring up is essential. Students or Associate Members of the Institution of Civil Engineers preferred.—Apply, at once, by letter, stating age, qualifications and experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W.1, quoting M/13740. J 393

THE RAILWAY CENTENARY.

THE celebration of the opening of the Stockton and Darlington Railway on September 27, 1825, is actually being held before its exact centenary, so that it may be combined with the present meeting of the International Railway Congress, the date of which could not be altered. The incident is typical of the character and history of the railway service. Many branches of engineering work involve a compromise between the suggestions of theory and the demands of practice, but none has to attend so strictly and in such various ways to the needs of practical circumstances and convenience, or is less tolerant of a theoretical suggestion that conflicts with them. The initiation of locomotive railways owed much to mechanical invention, but it owed more to the essentially scientific temper that accepted the needs of practice an inexorable load gauge for the constructions by which they were to be satisfied, to the perseverance with which men of mechanical genius developed those constructions to meet each need as it was discovered, and to the wise mutual confidence among those who founded it, whereby effective co-operation became possible. The opening of the Stockton and Darlington Railway was not the beginning of a new era in the development of the steam locomotive, though it gave an impetus to it that had been lacking up till that time. Its real distinction in history is that it marked the foundation of the public railway service. The development of that service has involved a great succession of changes and improvements, and the present celebrations are an occasion on which it may be fitting to review some of the principal stages by which this service has been evolved.

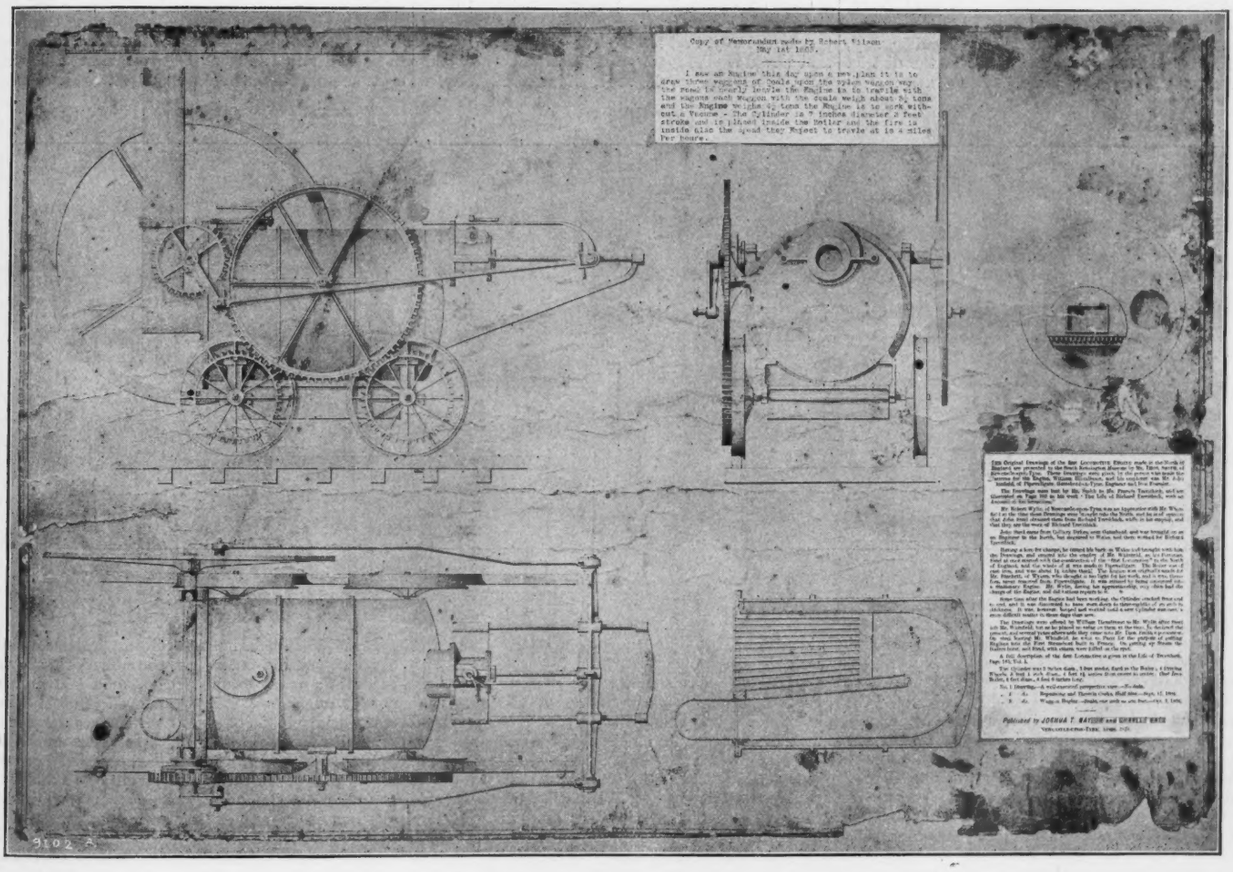

FIG. 1. REPRODUCTION OF ORIGINAL DRAWINGS OF TREVITHICK'S NEWCASTLE LOCOMOTIVE, 1805.

Neither railways nor locomotives were unknown in 1825. Railways or tramways were indeed fairly old, and the Stockton and Darlington line itself was promoted without any thought of mechanical traction, nor indeed did the Act of 1821 by which the line was authorised contain any powers to apply it. The Act provided for a railway or tramway for conveying merchandise by horse traction to be used by the public on payment of certain tolls. No authority was given either to use locomotives or to carry passengers. It was one among a number of schemes that Parliament had sanctioned for improving transport by canal or otherwise. Such improvement was demanded chiefly by the collieries and other mines, the cost of carriage of whose products was often much more than that of winning them. The burden had been recognised since the beginning of the eighteenth century, but the development of the country had made it much more acute. In the last half of this century the population had increased from 6,000,000 to 9,000,000, more than three times the increase during the first half. Its production had increased still more rapidly. With the succession of inventions that had converted textile manufacture from hand to mechanical processes, and the introduction of the steam engine, which had made it into a power-driven industry, the value of production of cottons had risen from 20,000*l.* in 1700 to 18,500,000*l.* in 1831, and that of woollens had trebled. Iron smelting with coal and Cort's introduction of puddling and rolling had brought pig-iron manufacture in England and Wales from 17,000 tons in 1740 up to 250,000 in 1806. Pottery production, profiting by Wedgwood's improvements in ware, not only absorbed most of the home market, but exported five times as much to all parts of the world. It was, indeed, no wonder that cheaper and more plentiful transport was demanded,

and that the carriage of goods was the most immediate object of those who were projecting new schemes.

After an unsuccessful struggle to make the connection by canal, the Stockton and Darlington Railway was surveyed with a view to horse-traction. Apparently it was with no thought of introducing steam that immediately on the Act being passed the directors decided to have the line resurveyed, and asked George Stephenson to undertake this work. Stephenson had by then become eminent as an engineer. It was known that he had made a locomotive, but entirely apart from that side of his work he had a considerable connection and a wide reputation for engineering work, with much experience in laying out railways for horse traction and in supervising their construction. Further, enquiry satisfied the directors that he was an "intelligent, active, experienced and practical man, assiduous in his attention to what he undertook and moderate in his charges," and on the faith of these virtues they appointed him engineer of the line three months after the Act had been obtained. They were quite clear that the line was, in the words of Edward Pease, the director who acted for the Board in the engagement of Stephenson, to be "a great public way, and to remain as long as any coal in the district remains." It was, however, to have as little machinery as possible, and except that it was to have iron rails the directors seem to have contemplated no modern improvements.

Looking back, it will be readily understood that the steam locomotive may not have commanded any great degree of confidence at the date in question. It had long been recognised as desirable. Newton as a boy made a suggestion and sketch, though of an impracticable device, and it was among the earliest of the suggested applications of Watt's engines. The first steam-propelled vehicle actually constructed and used seems to have been the steam carriage of Cugnot, which did actually travel with its load; but its imperfect steering gear and inadequate steam supply made it a failure in practice (see page 264 *ante*). One was made in 1769, and a second (Fig. 2 above), was constructed as an artillery lorry in 1770. Watt actually included a locomotive engine in his patent of 1784, and Murdoch, who was his assistant, made a working model of such a machine. Both the many other calls on his energies and his strong objection to using steam under any notable pressure prevented Watt from developing his non-condensing engine and the locomotive, and Murdoch, though he may not have shared Watt's objection to the use of non-condensing engines, was also too fully occupied in other ways to follow up his locomotive design to any great extent. The first really practicable locomotive was designed and made by Trevithick, who, with his cousin Vivian patented a steam carriage in 1802, and in 1804 modified it to a locomotive for rails. This was tried at the South Wales colliery where he was engaged. Though it seems to have worked quite well, it was not taken up in the neighbourhood; but Blackett, of Wylam Colliery, in Northumberland, was impressed with the result of the trial, and gave Trevithick an order for a similar locomotive. Trevithick sent up the drawings and patterns of this locomotive to John Whinfield, of Gateshead, his agent, by whom it was built in 1805. A reproduction of the drawings is shown in Fig. 1, page 783. Though for some reason the locomotive was never used on the railway, it was shown on a temporary track to work satisfactorily, and embodied essential features of subsequent locomotives. It had smooth wheels, furnished with flanges, and the combustion on the hearth was stimulated by turning the exhaust up the chimney. It was designed to haul about 10 tons at 4 m.p.h., and weighed 4½ tons. Although Trevithick built and exhibited other locomotives and steam carriages, he left England ten years later, and his work on locomotives remained without effect, except on the designs of his successors.

Like its South Wales predecessor, Trevithick's Gateshead locomotive was too heavy for the permanent way, and too light to secure the adhesion that would enable it to "pull its weight" economically. Accordingly, in 1811, John Blenkinsop, a viewer in a Yorkshire colliery, devised the road and rack locomotive shown in Fig. 7, Plate XLIX, and four engines of this type were made in 1812–13 by Fenton, Murray and Wood. The design was similar in a general way to Trevithick's, and was produced under his patent, the chief difference being that two cylinders were provided, working on cranks on separate shafts, and so connected that the cranks remained at right angles. Difficulty in starting was thus avoided. The engines weighed 5 tons and drew a load of 94 tons at 3¼ m.p.h. on the level, running light at 10 m.p.h. The use of a rack found application for heavy gradients in later years, but even in 1804 many people thought, like Trevithick, that it should be unnecessary on the level or on moderate gradients, and in 1811 William Hedley, the viewer to Blackett, made a model which tended to confirm this opinion. In 1813 Hedley, assisted by Jonathan Foster and Timothy Hackworth, made an engine for the Wylam colliery, in which two steam-jacketed vertical cylinders were used, which transmitted the power through grasshopper beams to a shaft with over-hanging cranks set at right angles. From these the drive was taken through gearing to the four driving wheels. Like Trevithick's, the boiler has an internal return furnace flue. The engine usually hauled about 50 tons at 5 m.p.h. It weighed 8·3 tons in working order. The heating surface was 77 sq. ft., and the steam pressure 50 lb. per square inch. In 1815 it was rebuilt as an eight-wheeler on two four-wheeled bogies, so as to distribute the weight more evenly over the cast-iron plate way. The method of enabling an engine to go freely round curves by carrying part of its weight on a bogie frame turning on a pivot had been patented by William Chapman in 1812, and was, in fact, applied by him in 1814 to an engine of his own design. Hedley's locomotive became well known as "Puffing Billy," owing to the smoke and noise it emitted. How far Hackworth, who while Hedley's engines were under construction was foreman smith at Wylam colliery, was responsible for the design can hardly be decided. Indeed, the circumstances under which these and the numerous improvements that followed in the locomotive in succeeding years were devised, make it difficult to attribute many of these improvements to individual designers, to the exclusion of others. The friends of the individuals seem to have been more concerned than the individuals themselves in claiming credit. The workers were for the most part content with getting their work done, and each helped the other willingly as occasion arose.

George Stephenson at this time was a man of 32, employed as superintendent engineer at the Killingworth Collieries of a group known as the Grand Allies. He had held this position for ten years, having previously been a directing engineer at another colliery, where he had been promoted from assistant fireman and plugman following upon an improvement he made on a Newcomen engine. He had begun work in the fields as a child of eight, and did not go into the colliery till he was 14 or 15; until he was 18 he could neither read nor write. While with the Grand Allies he had entire control of all the steam engines; but this could by no means have exhausted his work. In 1813 with the permission of his employers he began to practice as a civil engineer on his own account, superintending collieries in the district, altering their engines and railroads, constructing new engines, and laying down new lines. These circumstances are not merely matters of biographical interest. They illustrate part of the qualifications that enabled Stephenson to become the father of the railway service, when other men in no way inferior to him stopped short at producing inventions. His experience before he designed his first locomotive had covered every branch of work that was to enter into the railway service, when it was equipped for steam. It was in 1814, when he had just begun his independent practice, that Stephenson designed his first locomotive. It was a blend of Blenkinsop's with Hedley's, in which the advantage of Blenkinsop's use of two cylinders was combined with the use of smooth wheels and edge rails, as in Hedley's design. In collaboration with Ralph Dodds, a young viewer at Killingworth, he next eliminated the complication and wear involved in the driving gear by working through connecting rods off the rising and falling cross beam of the engine, the rods being furnished with cup and ball joints at their lower ends and attached to pins on the wheels. To keep the crank pins at right angles

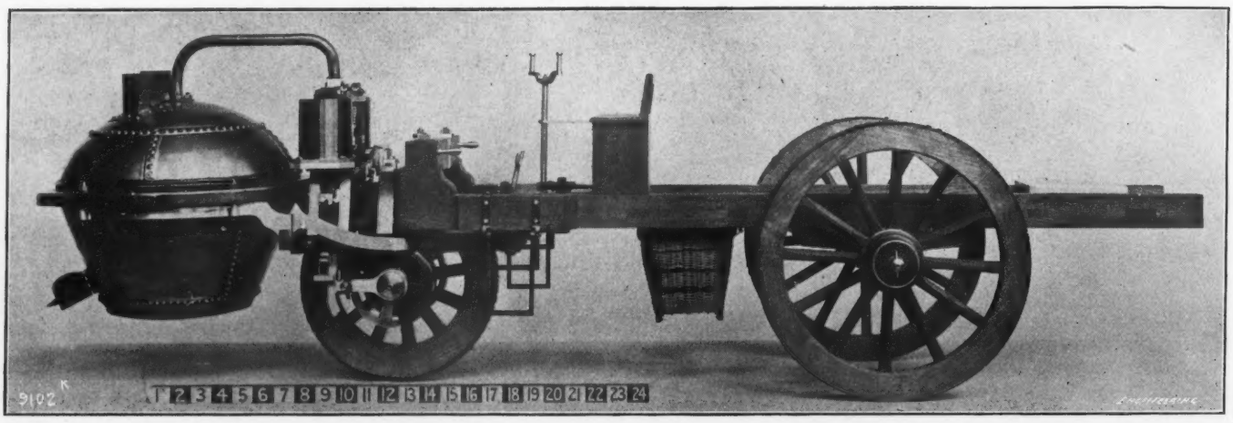

FIG. 2. CUGNOT'S STEAM CARRIAGE, 1770.

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

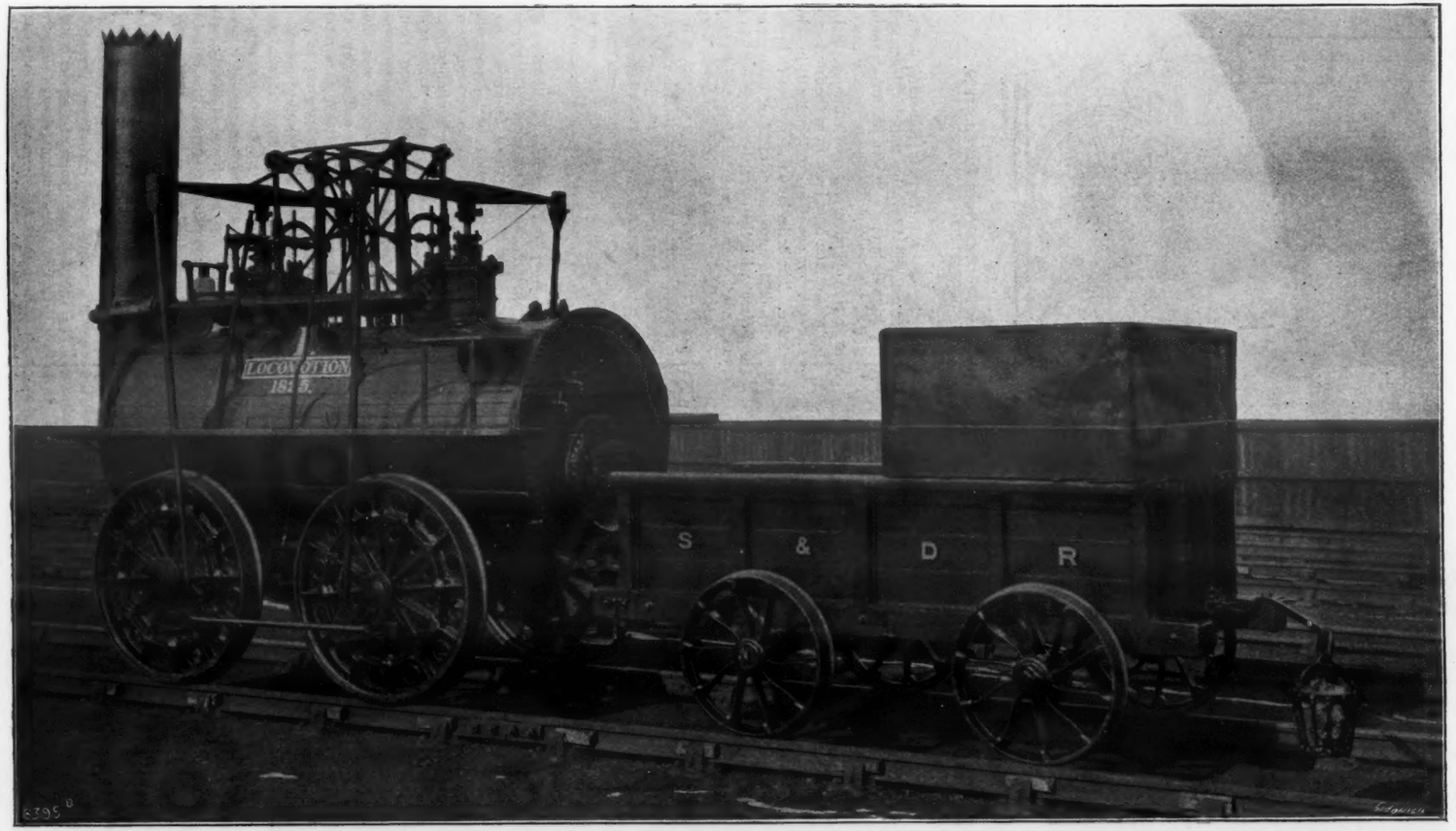

FIG. 3. LOCOMOTION NO. I OF THE STOCKTON AND DARLINGTON RAILWAY, 1825.

to each other Stephenson preferred to use cranked axles coupled by rods, but for the time being this method had to be abandoned owing to the difficulty of forging them sound and strong enough, and the axles were connected by a chain and sprocket drive. The use of these locomotives on the permanent way of the time caused considerable wear, and Stephenson addressed himself to improving the fixing and jointing of the rails. In a patent of 1816, taken out with William Losh, he described designs in cast iron for this purpose, and also developed a system of "steam springs," which, however, was subsequently displaced by plate springs. It was at this stage that, apparently quite independently, he re-invented the blast pipe.

Stephenson's engines ran on their lawful occasions on the Newcastle roads, in particular on that of Killingworth, and attracted the attention of engineers and promoters of railroads from abroad, as well as from various parts of this country. Numberless experiments, moreover, were made on them, both before and after the opening of the Stockton and Darlington line. When the equipment of that railway came to be discussed after Stephenson's survey in 1821, he was successful in satisfying his directors that locomotive traction would be to their advantage. His competence had been confirmed by the result of his re-survey, which gave a much easier and a cheaper route, and his independence by his recommendation of wrought iron rails instead of the cast iron in which he had a financial interest. In a further Act of 1823 power was taken to use steam locomotives on the line. The directors had in the previous year announced their intention of doing so. The connection that had arisen between Stephenson and Edward Pease gradually became more intimate, and in 1823 works for making locomotives and other engineering and millwrights' work were established by a partnership under the style of Robert Stephenson and Co., between Pease, Stephenson and his son Robert, and Michael Longridge, with a capital of 4,000*l*. Pease subscribed two-fifths of the capital, and found 500*l*.—out of the 800*l*.—to be subscribed by Robert; the other partners subscribed a fifth each. Robert Stephenson was made managing partner, but in 1824 he left England on a mining mission to South America, and Longridge, though he had joined only to look after the business end of the firm, undertook the management for the time being in his absence. At the end of 1824 it was agreed to form a second firm under the style of George Stephenson and Son, and to open an office for engineering and railway surveying. The success of the works was such that by 1831 they were unable to cope with all the orders there was reason to expect, and with the consent of the other partners Robert Stephenson was allowed to establish himself with others in locomotive works in Liverpool, under the style of Charles Tayleur, Junr., and Co., and

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

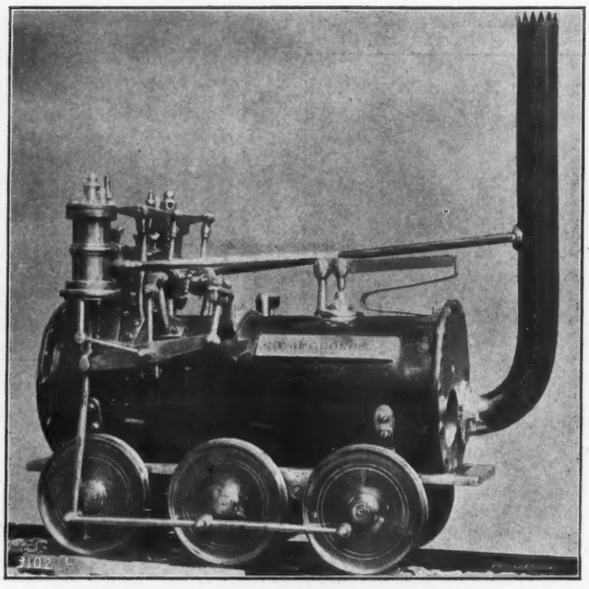

FIG. 4. HACKWORTH'S ROYAL GEORGE, 1827.

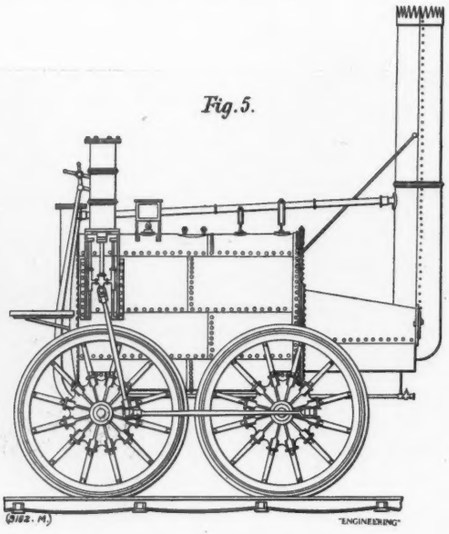

FIG. 5. HACKWORTH'S SANS PAREIL, 1829.

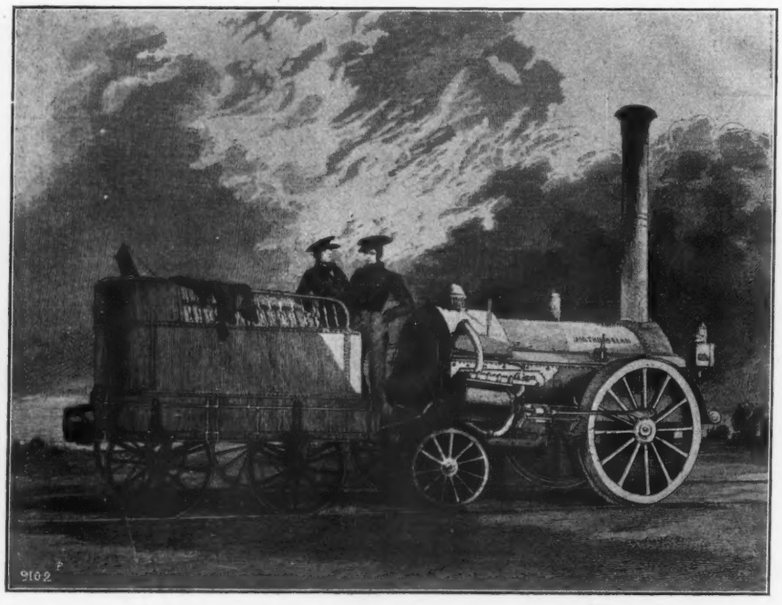

FIG. 6. STEPHENSON'S NORTHUMBRIAN, 1830.

divide his time and interest equally between the two works. In this way the Stephensons were brought into relation with the railway service they were to create with a peculiar intimacy, and no doubt can be felt that the rapid improvement in railway practice in the following twenty years owed much to that partnership. As the event turned out, Edward Pease had made a good bargain; but when he made it the railway movement was opposed bitterly and vigorously by supporters of canals, turnpike roads and other vested interests, and among its other characteristics the partnership was remarkable for a uniform goodwill and fair dealing among the partners.

It was with Robert Stephenson and Co. that, in the autumn of 1824, the Stockton and Darlington directors placed their first order for two locomotives. Of these only one was delivered by the date of the opening of the line a year later, making in all about 16 locomotives constructed by Stephenson since 1813. This No. 1 engine of the Stockton and Darlington, known as the Locomotion, ran on the line till 1846. It is still kept in working condition at Darlington, and Fig. 3, page 785, shows it as it now appears. Like previous designs, it has a pair of vertical cylinders arranged along the axis of the boiler, each driving by side connecting rods a pair of 48-in. cast-iron driving wheels, coupled by external rods, which keep the driving crank-pins of the front and rear wheels at right angles. The valves are driven by rocking shafts off a single eccentric on the leading axle, one shaft directly and the other through a bell-crank lever. The driver controls the valve rods for disengaging and reversing from one side of a platform running each side of the boiler. Two pipes convey the exhaust from the cylinders up the chimney, and a feed pump is driven by a lever from the front crosshead. The cylinders are 10 in.—originally 9½ in.—by 24 in. stroke. The boiler is 10 ft. long by 4 ft. in diameter, with a single through flue of 24 in. diameter connecting direct with the chimney, which is 15 in. in diameter. The heating surface is about 60 sq. ft. A single safety valve is provided, loaded by a weighted lever. In the early days the practice was to fix this valve when running, and two fatal boiler explosions occurred through neglecting to release it when the engine was standing. The wheel base is 5·17 ft.; the weight in working order is 6¼ tons (with tender about 9¾ tons), and with a boiler pressure of 50 lb. the engine was reckoned to develop about 10 h.p., and run at 8 m.p.h.

With this locomotive, followed by three others of similar design, the line was run. The conditions of traffic allowed it to be used by anyone for horse-drawn vehicles on payment of the prescribed toll, and the engines were thus so constantly held up, that ultimately the use of the line had to be confined to locomotives. The passenger steam traffic was trifling. Meanwhile experiment was being continued with the object of improving the locomotives. In 1827, for instance, an engine was built—the Experiment—with water-tube fire-bars and an internal water-drum, in addition to a return flue, two horizontal cylinders driving on to one axle, a feed heater, and other improvements. Being found too heavy for the road, it was placed on six wheels and on springs, and the results were so satisfactory that the other engines of the company were ordered to be altered similarly. Another, engine with modified design was the Royal George, built later in 1827 to the design of Timothy Hackworth, who on George Stephenson's recommendation had been appointed the company's locomotive superintendent. This was a conversion of an engine that the company had bought from an outside maker and had found unsatisfactory. Fig. 4 shows a photograph of a model made at the time. In this the cylinders, though they were vertical as in the earlier designs, were no longer arranged tandem along the boiler, but were placed side by side to drive direct on to the crank-pins of the trailing wheels. The engine was carried on six wheels, all coupled. In the following year the Lancashire Witch was built, in which cylinders inclined at 45 deg. were used, driving direct on to the wheels and thus simplifying the construction of the

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

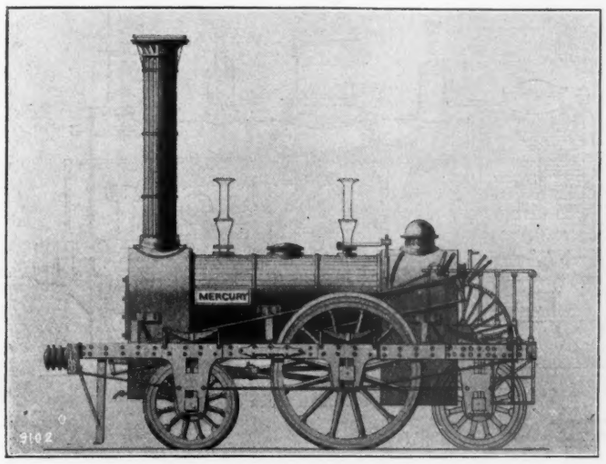

FIG. 14. STEPHENSON'S MERCURY, 1830.

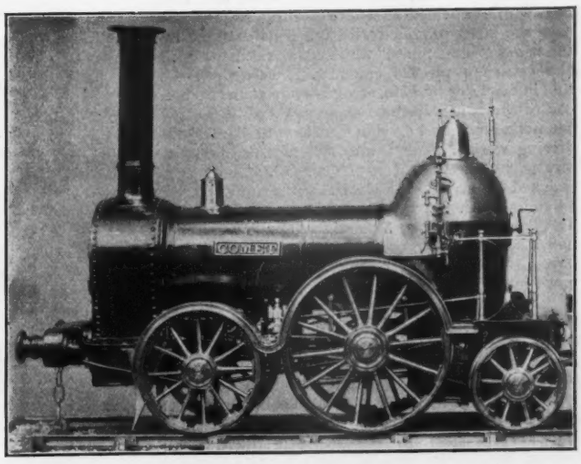

FIG. 15. BURY'S COMET, 1835.

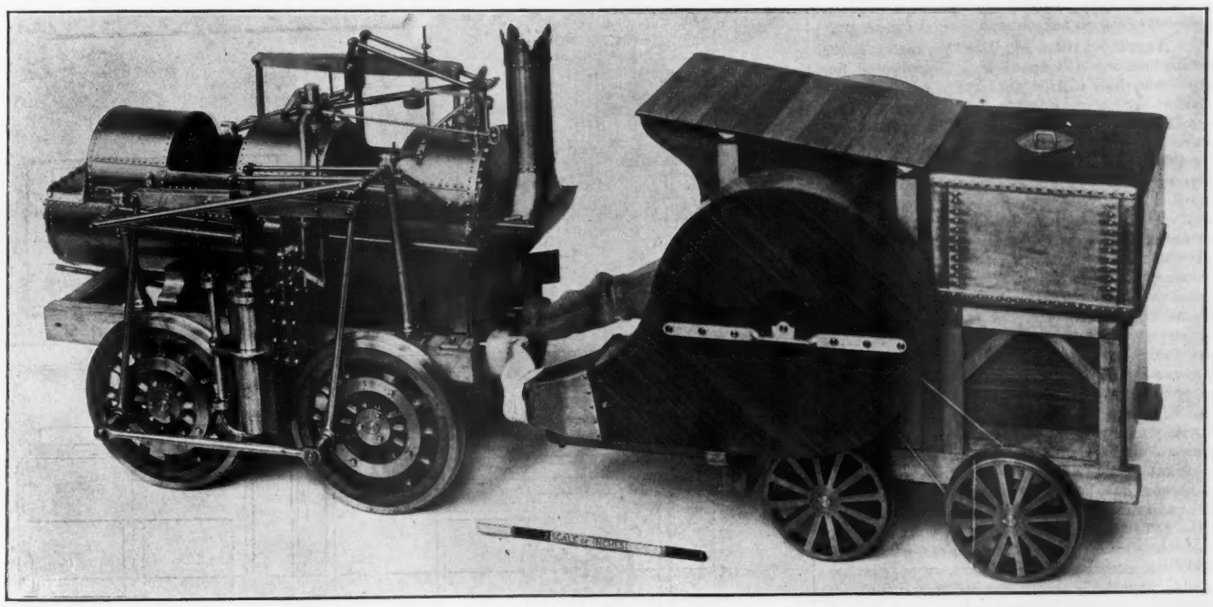

FIG. 16. SÉGUIN'S LOCOMOTIVE, 1829.

Experiment. A twin flue was also fitted, each flue containing its own grate. Forced draught was applied by a bellows to enable coke to be burned. The engine was carried on springs, and an expansion gear was fitted, to be applied by hand as desired. There is reason to think that by this time Robert Stephenson was taking an active part in the design of locomotives, and it is impossible to say how much of the further evolution of their design was due directly to his father. It seems clear that on the one hand George Stephenson, who had an increasing personal practice, could have had little time to spare for anything that his partners or staff could do for him, but that on the other he took an active interest in considering every fresh proposal for improvements or alteration of design, and his criticism was at all times welcomed and respected.

The calls on George Stephenson's personal time were considerably increased in 1826 by his appointment as Chief Engineer to the Liverpool and Manchester Railway. The line had been surveyed for the promoters by G. and J. Rennie, but the directors held it indispensable for the superintendence of the work to be done by a resident engineer, and as Mr. Rennie was unable to undertake this the appointment was given to Stephenson, who, in addition to his mechanical knowledge, was now reputed to have had more experience in constructing and working railways than perhaps any other individual. The work included one essential piece of civil engineering, namely, carrying the line over a bog on which cattle could not walk. This called for exceptional ability and courage, and the complete success with which Stephenson performed this task illustrates another side of his extraordinary accomplishments distinct from locomotive work. Beyond confirming and enhancing Stephenson's personal reputation the execution of this work had no immediate effect on the development of the use of locomotives. Later, as a consequence of differences of opinion as to the respective advantages of locomotives and stationary winding engines with rope traction, it was decided to offer a premium for the best locomotive. This offer was made in the spring of 1829, and trials of the competing engines were held at Rainhill in the autumn.

The state of the art at this date and the expectations of the promoters of the trials may be judged from the chief conditions of competition. The locomotives were required effectually to consume their own smoke in accordance with an Act of 1827. The weight, including water but not fuel, was not to exceed 6 tons, and if it exceeded 4½ tons it was to be carried on six wheels. Except for the Sans Pareil, no engine exceeded 4½ tons; all were on four wheels. The engine and boiler were to be supported on springs. The boiler was to work at not more than 50 lb. per square inch, controlled by a mercurial gauge to indicate the excess over 45 lb., and the machine run on the level was to draw day after day three times its own weight at 10 miles an hour. Of some ten engines prepared for the trials, three actually competed, and one only—Stephenson's

Rocket (Fig. 8, Plate XLIX)—went right through the tests, which represented on a 1½ mile track the journey from Liverpool to Manchester and back. The outstanding advance shown in the design of the Rocket was the multi-tubular boiler and fire-box, which provided adequate heating surface, the coke fire being provided with sufficient draught by the use of "blast pipes," which led the exhaust from the cylinders up the chimney. The cylinders—8 in. in diameter by 17 in. stroke—were at the firebox end of the boiler, inclined at an angle of 35 deg. to the horizontal, and driving direct on to the 56½-in. driving wheels. The frame was of flat bar iron, arranged entirely within the wheels. The whole weighed 4 tons 3 cwt. On the trials she averaged 14 miles an hour, with a maximum of 24 m.p.h. The Sans Pareil (Fig. 5), designed by Hackworth, had a return flue, water jacketed and projecting beyond the boiler on the fire grate side, with a very powerful exhaust blast, which removed a great deal of unconsumed fuel. According to the contemporary account of Nicholas Wood, one of the judges, quoted in Mr. Warren's *Century of Locomotive Building*, it had about two-thirds of the heating surface of the Rocket, but evaporated a third more water at more than double the cost of coke per pound evaporated. The cylinders were vertical, as in Hackworth's previous design. The third competitor, Braithwaite and Ericsson's Novelty (Fig. 9, Plate XLIX) was of entirely different design. It weighed only 2¾ tons, and used forced draught produced by bellows, the furnace gases passing through a long coil in a horizontal prolongation of its vertical boiler. The construction had no apparent effect on subsequent locomotive design.

By August of the following year, before the opening of the Liverpool and Manchester line, Stephenson had carried the design of the Rocket considerably further. In the Northumbrian (Fig. 6, page 786), the 3-in. tubes of the boiler had been reduced to 1⅝ in. and increased in number, so as to give the engine a heating surface of 412 ft., or over three times that of the Rocket in a boiler of the same diameter (3 ft.) and only 6 in. longer (6 ft. 6 in. long). The firebox was made larger, giving nearly half again as much heating surface as in the Rocket, and was made in one with the boiler shell, thus assuming the form which, after a certain experimental period, particularly between 1850 and 1860, became the normal type of locomotive fire-box. The frame was made of vertical plates or bars, which carried the axle-boxes. The cylinders, 11 in. in diameter by 16 in. stroke, were nearly horizontal, and worked direct on to 5-ft driving wheels, with 2 ft. 8 in. rear wheels and a wheel-base of 7·5 ft. The weight in working order was 7·3 tons, of which 4 tons were on the driving wheels. This engine led the procession on the opening of the Liverpool and Manchester line, and, except for its cylinders being still at the fire-box end, approaches closely the type on the lines of which the design of the locomotive was to be developed. Before the end of the year (1830) its successor, the Planet, was running; Fig. 14, page 787, shows the Mercury, which was practically identical in construction with it. In this the cylinders were horizontal and placed inside the frame and below the smoke-box, thus reducing heat losses. They drove on to a crank axle in front of the fire-box, which carried a larger weight than in the Northumbrian—about 5 tons out of 8 tons—with a corresponding increase of tractive power. In other respects the engine was much the same as the Northumbrian in design and dimensions.

Having regard to the importance of the multi-tubular boiler in permitting a sufficient generation of steam, it may be of interest to refer shortly to the Séguin locomotive, shown in Fig. 16, page 787.

Séguin was a French engineer, interested in an intended railway from St.-Etienne to Lyons, who at the end of 1827 visited England and saw George Stephenson and his engines. What he saw on the Stockton and Darlington line decided him to lay out his line with a view to locomotive traction. The French company subsequently got Stephenson to go over and advise on the plans of their engineers, and the Government allowed two Stephenson locomotives to be introduced duty free for the guidance of Séguin and another manufacturer. Séguin had patented a multitubular stationary boiler just before coming to England, and in March, 1830, took out a second patent for a locomotive with a different form of multitubular boiler. In the autumn of 1829, two months after the first trial of the Rocket, a trial was made of Séguin's locomotive, which was driven under forced draught by a fan. French patents in those days were not published till their expiration, and the claim, made at a later date, that the use of a multitubular boiler on the Stephenson locomotive arose from Séguin's invention may be dismissed. Indeed even in this country the publication of a patent specification at the beginning of last century consisted of permission, for a high fee, to read it in a manuscript kept as a Chancery Record in London. No notes were allowed to be taken, and to obtain a copy was an extremely costly business. The mere fact, therefore, of an invention having been patented at an earlier date raises no presumption at all that it was known to a later inventor. As a fact the multi-tubular boiler was patented early in 1826 by James Neville, a London engineer, who shortly afterwards in another patent proposed to apply it to a steam carriage. Séguin retired after making the St. Etienne-Lyon line, and devoted the rest of his life to purely scientific study. He was unquestionably an able man, seeking apparently no public honours, and his fame will not be increased by the suggestion, made after his death, that he was the French Stephenson. It could hardly have been made by anyone, such indeed as Séguin himself, who knew the character of Stephenson's work; and perhaps

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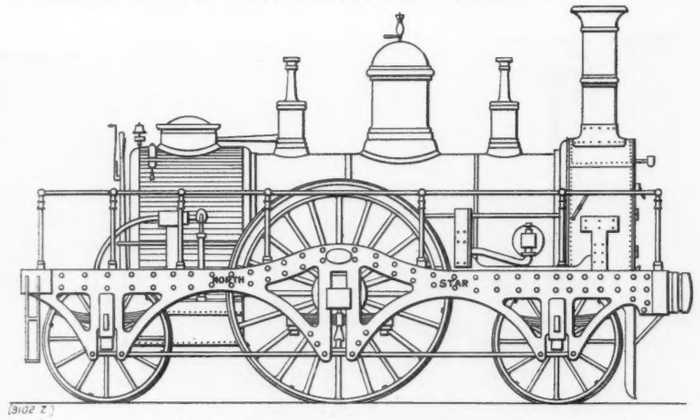

FIG. 17. STEPHENSON'S NORTH STAR, 1837.

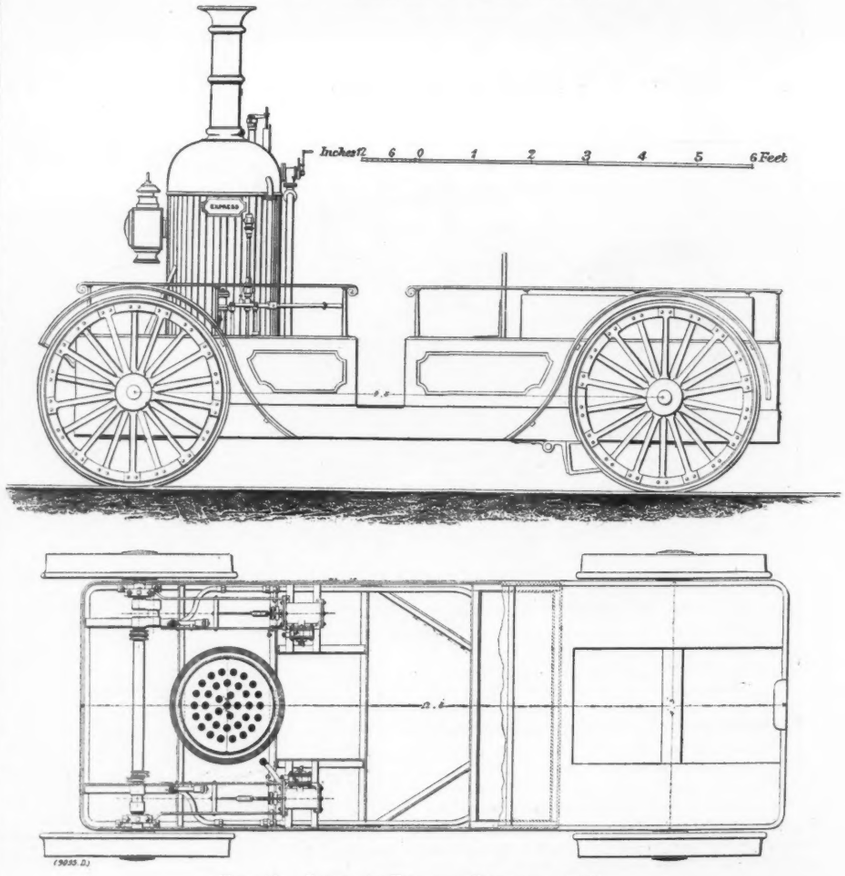

FIG. 18. SAMUEL'S EXPRESS CARRIAGE, 1848.

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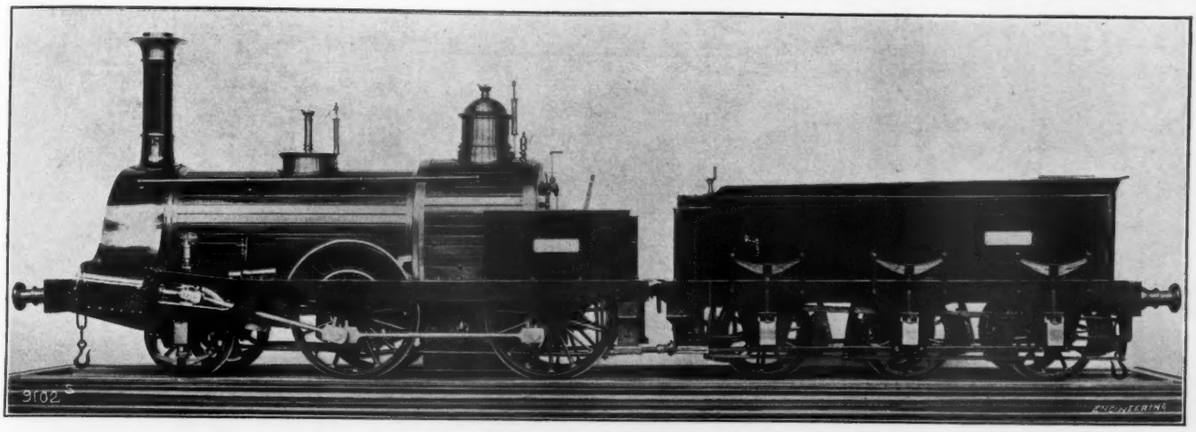

FIG. 25. ALLAN'S CREWE TYPE, 1843.

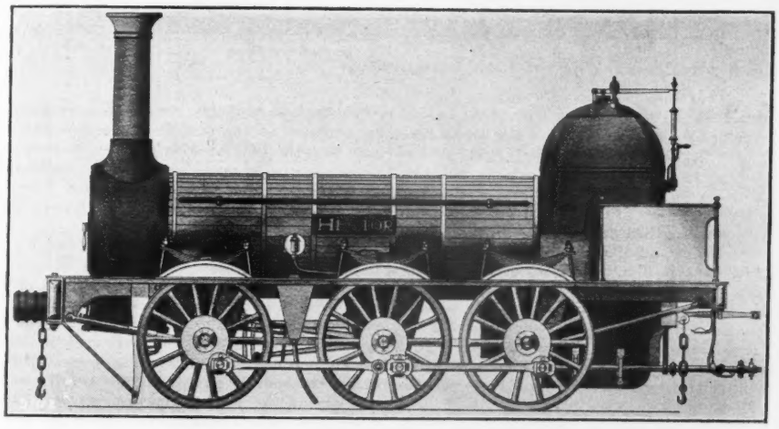

FIG. 26. KITSON'S HECTOR, 1845.

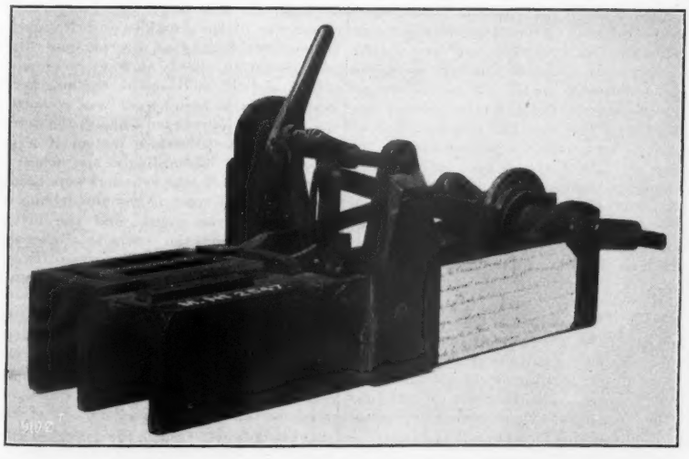

FIG. 27. HOWE'S LINK MOTION, 1842.

no better illustration of the difference between the two in their attitude to practical railway work can be wished than a comparison of the locomotives produced by the Stephensons in 1830 with that which Séguin produced in the same year.

The Planet, though having practically the same dimensions and heating surface as the Northumbrian, proved to be a much more powerful engine, and it practically settled the leading lines of the design of Stephenson engines for some years. Modifications in detail were constantly being tried and adopted, and as the size of the locomotives increased and unsteadiness was caused by the projecting firebox, a pair of wheels was added at this end behind the firebox. In 1831 it was desired to have a locomotive that would draw loads up certain inclines on the Liverpool and Manchester line, which had been designed to be worked by stationary engines, and on which several of the then existing locomotives were needed to handle any substantial load. For this purpose the Samson and the Goliath were built with 14-in. cylinders instead of the 11-in. on the Planet, and somewhat larger boilers and grates, giving about 10 per cent. more heating surface and rather more than proportionate grate area. The driving and leading wheels were reduced to 4 ft. 6 in. and were coupled, and thus the entire weight of 10 tons was available for adhesion, about double that of the Planet. These engines were completely successful for their purpose, and confirmed the view that had been taken of the Planet construction. It may be said, in fact, that for the first time definite lines of design had been laid down, which were sufficient to guide an increasing manufacture for some years, and in certain respects have never been displaced. The progress that the Stephensons had made in six years, mainly through their improvements in design and in a far smaller measure by increase of weight, is seen on comparing the leading figures of the Samson with those of the Killingworth and Hetton engines running in 1825. The weight had, in fact, only increased by one-third—7½ tons to 10 tons; but in round figures the heating surface was 11 times as great and the evaporation 10 times, while per ton of engine weight nine times as much heating surface was obtained and five times the power.

By this time the manufacture of locomotives was beginning to attract the attention of other manufacturers, and in particular, Bury, of Liverpool, began to specialise in them, building his first engine in 1829. This was a failure; but in 1830, having been joined by James Kennedy, who in 1824 had been engaged with the Stephenson firm, a revised design was produced in the Liverpool, which gave more satisfactory results. It was of importance chiefly because in 1837 Bury became locomotive superintendent of the London and Birmingham Railway, and his type of engine was used on that line for some years. Indeed, at the outset, though the 36 engines with which the company started had been made by six different makers, including Bury's own firm, from the same designs, they were let to Bury under contract to keep them in repair and provide the company with motive power at an inclusive price per mile. The Liverpool of 1830 had inside cylinders under the smoke-box, driving on to a crank axle with four 6-ft. wheels coupled, the axle being carried in two inside bearings. The boiler had a firebox D-shaped in plan, with a high domed crown. Fig. 15 (page 787) shows a model made in 1846 of an 1832 engine of this type, but with six wheels, a modification that Bury had ultimately to accept. A later form of this design was the Wrekin, stated by Bury to be "similar, in all the principal

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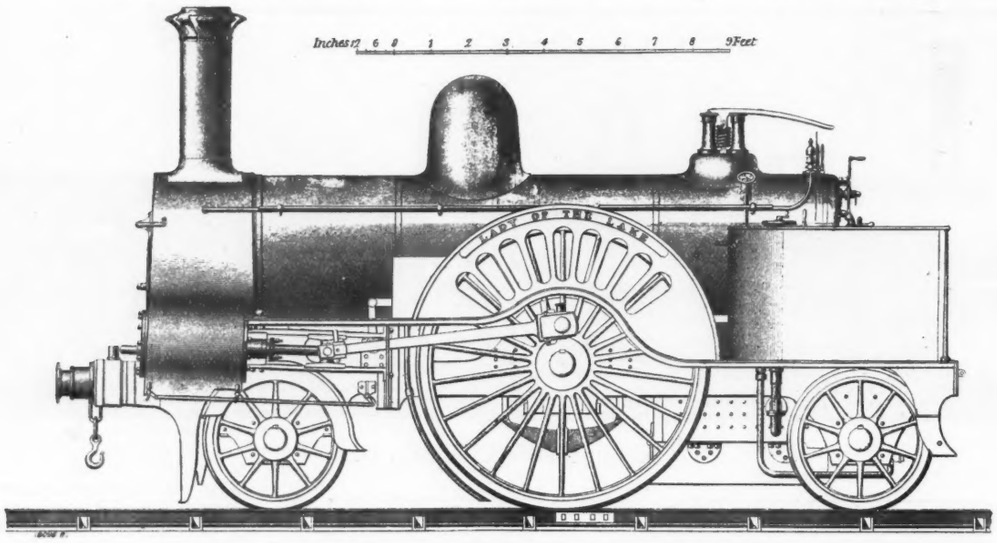

FIG. 28. RAMSBOTTOM'S LADY OF THE LAKE CLASS, 1859.

parts, to the 'Liverpool' locomotive engine, built . . . in 1830, except that in view of its extra weight it was placed on six wheels," is shown in Fig. 11, Plate L. It will be observed that by this time, apparently about 1846, the high-domed firebox had been abandoned, and the engine had single drivers; the valve gear had also been altered to correspond with the improvements indicated by Howe. Another example of a non-Stephenson engine of this period is shown in Fig. 10, Plate XLIX illustrating the Comet, built by R. and W. Hawthorn in 1835 for the new Newcastle and Carlisle Railway. It was notable for using four fast eccentrics in its valve gear in place of two loose ones, though it did not have the jaws on the eccentric rods introduced by the Stephenson firm, who had themselves adopted the four fast eccentrics at about the same time.

Both consideration for the permanent way and the recognition that further engines would have to be more powerful and heavier still, led the Stephensons to consider the use of a third axle on locomotives of the Planet type, and in 1833 Robert Stephenson patented a six-wheeled locomotive with the driving wheels without any flange, so as to reduce the strain on the crank axle, the purpose of the extra wheels being declared to be to allow the use of a larger boiler and firebox. The wheels were all to have bearing springs. The specification is also notable for describing a steam brake to be applied to the driving and trailing wheels. On this system the Patentee was constructed, and its general design became standard for British passenger locomotives for many years. Fig. 12, Plate L, shows the Harvey Combe, built in 1835, and selected by Robert Stephenson to illustrate the type. The driving wheels were 5 ft. in diameter and the leading and trailing wheels 3 ft. 6 in. The engine had both inside and outside frames, with bearings for the crank axle in each; the difficulty of lining these up was Bury's chief reason for preferring to have only inside frames. The cylinders were 12 in. in diameter by 18 in. stroke, and the engine weighed just under 12 tons.

Up till this time George Stephenson had set his face against wheels of more than 5 ft. diameter for the locomotives of the Liverpool and Manchester, and when Bury desired to supply that line with a locomotive the acceptance of his offer was made conditional on his driving wheels being reduced to that diameter. The normal speed on then existing railways would sometimes run up to 35 or 40 m.p.h., and had been known to reach 50 or 60, though 20 to 25 was more usual; but the higher speeds undoubtedly meant a high piston velocity and probably undue wear. Brunel, however, in laying out his plans for the Great Western Railway, which opened in 1838, was set on having a higher speed than had previously been usual without an excessive piston velocity, and accordingly required a larger wheel diameter. Both in Russia and the United States, with gauges of 6 ft. and 5 ft. 6 in. respectively, a similar desire was felt, and in 1836 Stephenson made for these countries engines on the 1833 standard lines, but with 6 ft. and 6 ft. 6 in. driving wheels respectively. To meet Brunel's views he built in 1837 a similar engine—the North Star—but with 7 ft. driving wheels. It was in general appearance as Fig. 17, page 788, with 16 in. by 16 in. cylinders and a rather larger boiler and wider firebox than the Stephenson standard of that date, but otherwise quite similar.

Among the circumstances restricting the further increase of locomotive dimensions was the size of existing turntables, which limited the wheelbase. This had already reached 11 ft. 8 in. on a narrow gauge engine of Stephenson's 1833 type, and in order to obtain more boiler space it would have been necessary on that design either to increase the diameter of the boiler, imposing a greater weight on the leading wheels, which in this type of engine was thought undesirable, or to increase the wheelbase, which the size of the turntables would not allow. The design had also the disadvantage of involving in the larger sizes a greater increase of firebox than of tube surface, and consequently excessive smokebox temperatures and consumption of fuel. To meet these objections and provide a considerable margin for increase of size Robert Stephenson designed his "long boiler" engine of 1841, in which all three axles were arranged in front of the firebox, larger boilers could be used without increasing the wheelbase, and a larger area of heating surface obtained in the boiler per foot of heating surface in the firebox. Various other improvements in fittings or parts were also described; but, apart from the rearrangement of wheels, the most notable was the abandonment of the outer frame and the adoption of a single-plate frame within the wheels. Both in this respect and in the use of an overhanging boiler, to which he had always objected up till then, Robert Stephenson showed the characteristic readiness of his father and himself to accept the dictation of experience. Bury on his own London and Birmingham line had persistently used locomotives with overhanging fireboxes and a comparatively short wheelbase; and Stephenson avowed frankly that, in face of the experience of such engines having run uninterruptedly over a series of years with an enormous traffic and no accident arising from the construction, the objection to this design could not be maintained. Similar considerations probably contributed to determine his omission of the outside frame. As had been done with the 1833 six-wheeled type, the long-boiler locomotives were made with various combinations of wheel coupling, and the 6-coupled type continues to be one of the standards in Europe up till the present time.

The dominant consideration in the design of the long-boiler locomotives was economy of fuel, and this they were found to effect. The next demand was for increased speed. It arose out of the discussions on the choice of rail gauges, and was accentuated by the trials that were made in order to settle questions in dispute. The acute differences of this battle of the gauges did not arise of a sudden, and during the preliminary discussions it became evident to Robert Stephenson that a demand was likely to arise for a locomotive possessing the advantages of the long boiler type, but able to run steadily at higher speeds than had been contemplated in their design. The design as it stood in 1845 did not fulfil these requirements. The experience of the London and Birmingham with locomotives having an overhanging fire box had not related to speeds such as were now contemplated, and the tendency of the long boiler type to unsteadiness at high speeds was accentuated when the cylinders were fixed outside the frame, as was done in order to reduce danger if a crank axle should break. Accordingly the wheel base was extended to 12 ft., the cylinders were brought within the wheels and much nearer the driving wheels and the centre of the engine, and the driving wheels were shifted from the centre to the smoke box end of the boiler, converting the locomotive into a rear-driver. The resulting locomotive, known only as A, is shown in Fig. 13, Plate L.

While the locomotive to this revised design was being made, the enquiry into the relative merits of the broad and the narrow gauges was held, and so far as concerned locomotives the issue seemed to be whether, on the narrow gauge, locomotives could be made as safe and, within the limits of what was or was likely to be wanted, as powerful as on broad gauge. It was decided that the matter should be decided by trials in the presence of Commissioners. These were reported to show that while the narrow gauge engine was the less steady, the unsteadiness was unimportant; there seems to be little doubt that the permanent way was not fit for the speeds in question. So far as comparison could be made in regard to efficiency the broad gauge engine appeared to be slightly more powerful, but markedly less efficient in evaporating power. As a consequence it was held in effect that these trials showed no practical difference between the locomotives

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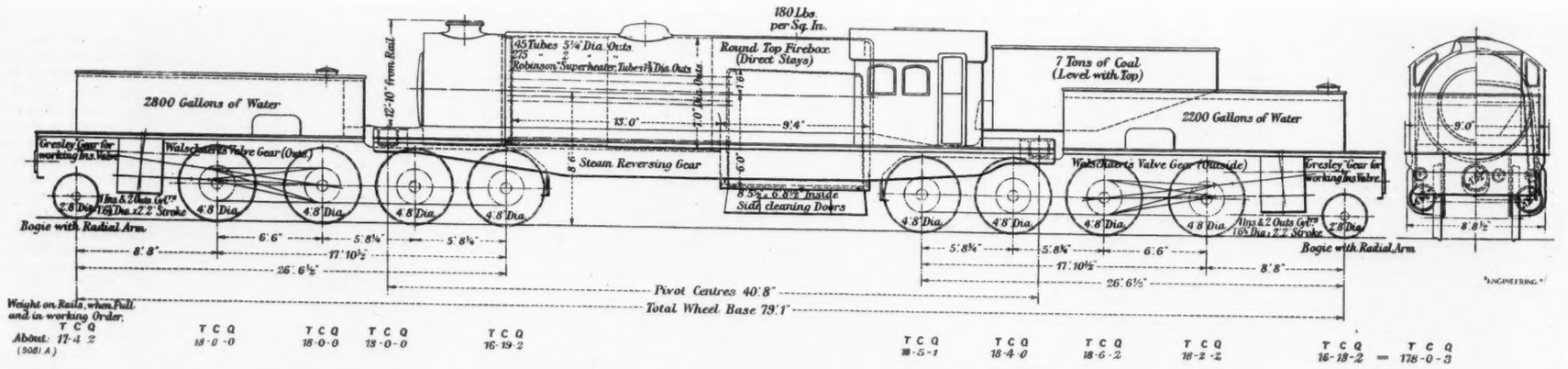
180 Lbs. per Sq. In.
45 Tubes 5¼" Dia. Outs
275 - 2 " "
Robinson Superheater Tubes 1⅝ Dia. Outs
Round Top Firebox (Direct Stays)
7 Tons of Coal (Level with Top)
2800 Gallons of Water
2200 Gallons of Water
Gresley Gear for working Ins. Valve
Walschaert's Valve Gear (Outside)
Steam Reversing Gear
8 Sq. Ft. Grate Area
8'5½" x 6'8½" Inside Side cleaning Doors
Bogie with Radial Arm
Pivot Centres 40'8"
Total Wheel Base 79'1"
Weight on Rails when Full and in working Order
About: 177-4-2 (908) A
178-0-3

FIG. 43. 2-8-8-2 GARRATT LOCOMOTIVE; LONDON AND NORTH EASTERN RAILWAY, 1925.

compared that could affect the disadvantages of diversity of gauges.

Gooch on the Great Western was by no means prepared to accept this decision as justified, and designed his Great Western class, in which the power and speed were considerably increased. The second of this class was the Iron Duke, built at Swindon in 1847, a view of which is given in Fig. 19, Plate LI. It will be seen that it had single drivers, which were 8-ft. in diameter, and two pairs of leading wheels. Its total heating surface was 1,952 sq. ft., its grate surface 21 sq. ft., and its cylinders 18 in. in diameter by 24 in. stroke. The engines of this class continued to work the broad gauge service until it was wholly converted. Stephenson left well alone, and turned to satisfying the demand for engines of the A type. On the other hand Crampton, formerly Gooch's chief draughtsman, designed his Liverpool (Fig. 20) with the object of meeting the Great Western challenge. Bury, Curtis and Kennedy built the engine in 1848. It was an eight-wheeled single driver, with 2,290 sq. ft. of heating surface, and 21½ sq. ft. of grate area. The cylinders, 18-in. in diameter by 24-in. stroke, were arranged outside the wheels. The driving wheels were 8 ft. in diameter and the leading wheels 4 ft. The driving axle was arranged behind the fire-box, so as to bring the centre of gravity of the engine lower than was possible in the broad gauge engines, with driving wheel axles passing under the barrel of the boiler. Tried on the L. & N.W.R., it was reported to pull the load of three ordinary engines, and with a light load did 78 m.p.h. in 1849. The type was used considerably on the Continent, and to some extent in this country.

The extent to which the 1833 Stephenson type established itself in the railway service may be seen by comparing the Harvey Combe with the Jenny Lind, built in 1846 by Messrs. E. B. Wilson and Co., and for some time one of the most esteemed standard classes of passenger engine. By the courtesy of the Institution of Mechanical Engineers, we give in Fig. 21, Plate LI, a view of the Jenny Lind from a drawing by David Joy, who worked on her. The class was made in various sizes, distinguished by their heating surface; the one shown in the figure was of the 1,000 sq. ft. class, actually having 1,031 sq. ft., and weighed 25 tons, with cylinders 15 in. in diameter by 24 in. stroke, and wheels 5 ft. and 3 ft. 6 in. in diameter. These dimensions all round are of the order of something over double those of the earlier locomotive, and the general similarity of the two designs is evident.

An incidental reaction from the tendency to increasing size is seen in the express carriage designed by James Samuel in 1848 (Fig. 18, page 788), intended primarily for inspection work and small branch lines. Its vertical boiler was 1 ft. 7 in. in diameter by 4 ft. 3 in. high, with a fire-box and tubes giving in all 43½ sq. ft. of heating surface. Its vertical cylinders on either side of the boiler were 3½ in. in diameter by 6 in. stroke, and drove on to a cranked axle. Carrying seven persons, it ran normally at 30 m.p.h., with a consumption of just over 3 lb. of coke per mile.

Another locomotive resembling the Stephenson type of the day was the Hector, built by Kitson and Co., in 1845 (Fig. 26, page 789). This was a six-coupled engine with 4 ft. 9 in. wheels, inside frame, and a haystack firebox. The cylinders were 15 in. in diameter by 24 in. stroke.

A typical single six-wheeler built in 1848 for high speed was R. and W. Hawthorn's Plews (Fig. 22, Plate LII). In general this followed the Patentee type. The cylinders, 16 in. in diameter by 20 in. stroke, were inside and bolted to an outside frame, and were so arranged that the boiler came within 6 in. of the crank-axle. The driving wheels were 7ft. in diameter and the others 4ft., and in travelling 70 m.p.h. the engine is said to have been free from pitching and economical of coke.

An example of a goods engine built about the same time is represented in Fig. 25, taken from a model of an engine built by E. B. Wilson and Co. in 1856 for the Bombay, Baroda, and Central India Railway, then in process of construction. It followed almost identically Allan's Crewe class of goods' engines, which were built regularly at Crewe from 1843 to 1857. It had outside inclined cylinders, 14 in. in diameter by 24 in. stroke, and four coupled driving wheels, 5 ft. in diameter. It had double framing, the cylinders and axle boxes for the coupled wheels being carried on the inside frames, and the axle boxes for the 40 in. leading wheels on the outer frames. The engine was fitted with Howe's link motion with suspended valve rods; the two feed pumps were driven from the two inner eccentrics. As was usual till some time later, the braking was done on the tender, blocks being applied by a hand-wheel and screw to the three wheels on one side.

The most successful type of passenger engine produced at Crewe at a little later date was the Lady of the Lake (Fig. 28, page 790), built by Ramsbottom in the Problem class from 1859 to 1865. It had slightly inclined outside cylinders, 16 in. in diameter by 24 in. stroke, with steam chests passed through the frames, and valves driven by Howe's link motion, controlled from the footplate by a hand wheel and screw. It was a single driver, with 7 ft. 7½ in. driving and 43½ in. trailing wheels, the leading and driving axles having plate springs and the trailing axle with six volute springs above it. It had sandboxes in front of the driving wheels and a Ramsbottom scoop on the tender for picking up water while running. Its weight in working order was 27 tons, and the heating surface 1,013 sq. ft. in addition to 85 sq. ft. in the firebox. As with the Allan engines the only brake was on the tender.

A remarkable type of double-bogie locomotive by Fairlie was introduced in 1864, and Fig. 23, Plate LII, shows its application in 1870 on the Festiniog light (1 ft. 11½ in. gauge) railway. This was a 4-cylinder engine, with each pair of cylinders arranged within the frame of a separate bogie. The boiler was mounted on the centre of the two frames and provided with two fireboxes and a cab at the centre of the locomotive which had a smoke-box at each end. Each bogie was carried on six coupled wheels, and supported half the weight of the pivoted boiler. The engine was fitted to run in either direction, so avoiding the use of turntables. The valve gear was of the stationary link type, operated by rocking shafts as shown, and the regulator valves were connected and operated by a single handle. The rigid base of each engine was 5 ft. in the locomotive here illustrated, so that it could go readily round extremely sharp curves. The cylinders of the illustrated engine were 8⅛ in. in diameter by 1 ft. 1 in. stroke, the wheels 2 ft. 4 in. in diameter, heating surface 730 sq. ft., working pressure 160 lb., and weight in working order about 19½ tons. In a larger size, however, built by Messrs. Neilson, the cylinders were 16 in. in diameter by 22 in. stroke, the driving wheels 45 in. in diameter, heating surface 1,813 sq. ft., and rigid bases for each engine, 8 ft. 3 in.

A class of locomotives that worked the Great Northern express traffic successfully for thirty years was the single driver type of Patrick Stirling, introduced in 1870 (Fig. 24, Plate LII). They were distinguished by their 8-ft. driving wheels, and their designer attributed their success largely to the weight, carried by the leading wheels. This was distributed between two bogie axles before and

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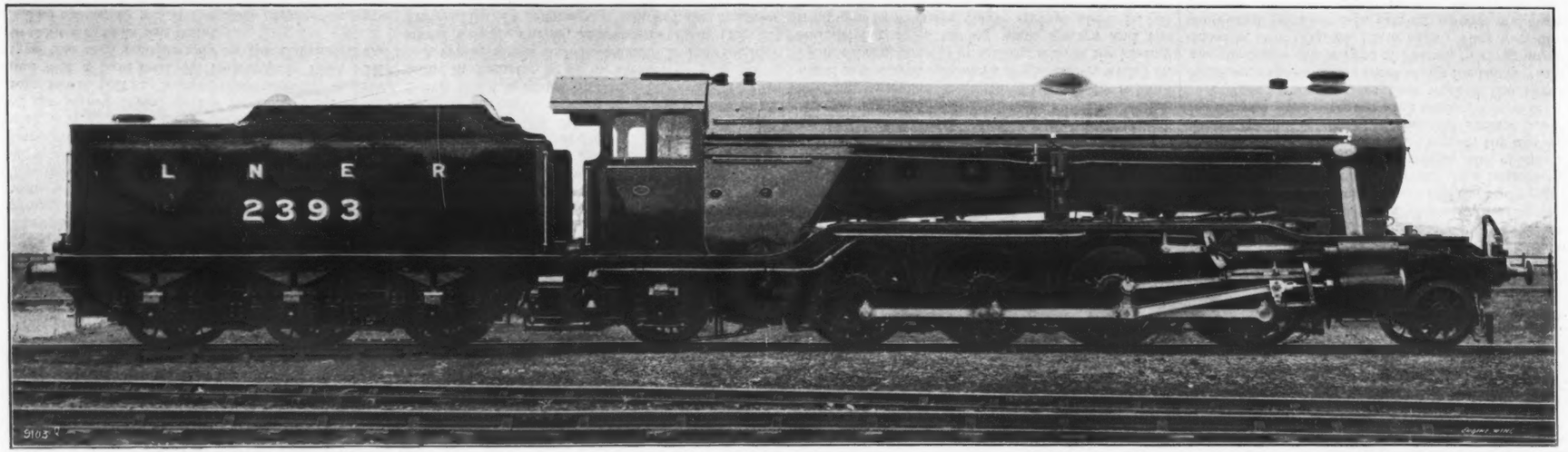

FIG. 44. 2-8-2 TYPE FREIGHT LOCOMOTIVE; LONDON AND NORTH EASTERN RAILWAY, 1925.

behind the smoke-box, and served to hold the road down in front of the driving wheel. The cylinders were placed outside the frames and were of 18 in. in diameter. The total weight of the engine was 44 tons, of which 16 tons, or sometimes more, were carried by the drivers.

With these examples of the practice of the first half-century of railways may be considered a few of the most recent locomotives, which the courtesy of their designers allows us to reproduce.

Figs. 29 and 30, Plate LIII, show the well-known three-cylinder class of the Great Northern Railway 4-6-2 type, previously fully described in ENGINEERING. Its leading dimensions will be found in the outline drawing, and the particulars given previously renders a detailed description unnecessary. With its tender it weighs in working order 148 tons 15 cwt., against the 4½ tons of the first Liverpool and Manchester engines. The advance in power may be gathered from the fact that it will take over 600 tons of load at an average speed of 50 m.p.h., which on occasion may exceed 70 m.p.h. Such speeds were known in engines of the '40's, though not maintained as they are at the present day. The real progress has been in power. The loads with which these speeds are now attained are at least ten times what they were then, and the means by which the engines are made to carry out this heavy work regularly with less need for repairs than their relatively small predecessors with their less duty, are the accumulation of the experience in the interval and the continual enterprise in designing that has distinguished British locomotive building from the outset.

A still newer locomotive is shown in Figs. 31 and 32, which represent the latest 4-6-0 type engine of the Southern Railway. They are a continuation of the King Arthur class, modified in several important particulars by Mr. R. E. L. Maunsell, the Chief Mechanical Engineer. Thirty-six of them are now being delivered by the North British Locomotive Company of Glasgow. Generally they are similar to the latest South Western Section express engines with 6 ft. 7 in. wheels, and their overall dimensions enable them to run on any section of the Southern Railway. The cylinders are 20½ in. in diameter by 28 in. stroke, and the working steam pressure is 200 lb. per square inch. The valve gear gives a travel of about 6⅜ in. to the piston valves in full gear. The boiler is standard for the class, but fitted with the Maunsell superheater, having header vacuum relief valves. Ross safety valves are fitted, and Ashford sight-feed lubricators feed into the steam pipes. Laminated springs of long span with links in tension and rubber pads are fitted under all the coupled wheel axle-boxes; a pump is provided to maintain the vacuum for the brake. The tender is carried on two four-wheeled bogies and takes 5,000 gallons of water and 5 tons of coal. The piston valves are 11 in. in diameter; the heating surface 1,878 sq. ft., and the superheating surface 337 sq. ft., with a grate area of 30 sq. ft. The bogie wheels are 3 ft. 7 in. in diameter. The weight of the engine and tender in working order is 138 tons 10 cwt, of which 60 tons are on the coupled wheels. The tractive effort at 85 per cent. boiler pressure works out at 25,320 lb., or 422 lb. per ton.

Of the London, Midland and Scottish Railway, Figs. 33 to 36, Plate LIV, show two four-cylinder engines, the leading dimensions of which are shown in the diagrams. No. 10,451, the four cylinders of which are 16½ in. in diameter by 26 in. stroke, has 1,893 sq. ft. of heating surface and 430 sq. ft. of superheater heating surface, with a grate area of 27 sq. ft. The total weight of the engine and tender in working order is 119 tons 1 cwt., and the weight per foot run on the coupled wheels is 4 tons 7 cwt. 1 qr. 8 lb., the tractive effort working out for 85 per cent. boiler pressure at 29,470 lb., and 80 per cent. at 27,736 lb. The working steam pressure is 180 lb. per square inch. No. 5969 has 2,128 sq. ft. of heating surface, including superheater tubes, and a grate area of 30·5 sq. ft. The weight of the engine and tender in working order is 117 tons 10 cwt. The maximum tractive force works out at 22,710 lb. at 80 per cent., or 24,130 lb. at 85 per cent. boiler pressure.

Figs. 37 to 40, Plate LV, show the latest classes of locomotives on the Great Western Railway of the four-cylinder 4079 4-6-0 type, and two-cylinder 4700 2-8-0 type. The leading dimensions and weights are shown on the diagrams. The cylinders of the former are 16 in. in diameter by 26 in. stroke, with steam ports 25 in. by 1¼ in. and exhaust 25 in. by 3 in. It has 2,049 sq. ft. of heating surface, and 262 sq. ft. for the superheater tubes with 30·28 sq. ft. of grate area. The working pressure is 225 lb. per square inch. The bogie wheels are 3 ft. 2 in. in diameter and the coupled 6 ft. 8½ in., the traction effort working out at 31,625 lb. The 2-8-0 type engine has cylinders of 19 in. in diameter by 30-in. stroke, steamports 31½ in. by 1¾ in. and exhaust 31½ in. by 3¾ in. The heating surface is 2,232 sq. ft., with 289 for the superheater, and grate area of 30·28 sq. ft. The wheels of the leading truck are 3 ft. 2 in. and the coupled 5 ft. 8 in., the tractive effort working out at 30,460 lb.

The engine which we illustrate in Figs. 41 and 42, Plate LVI, and Fig. 43, page 791, has just been completed by Messrs. Beyer, Peacock and Co., Ltd., of Gorton, to the designs of Mr. H. N. Gresley, C.B.E., for the London and North Eastern Railway, and represents a considerable advance on Garratt locomotives previously manufactured. It is the heaviest and most powerful of the type in the world. Of the 2-8-8-2 type with three 18½ in. by 26 in. cylinders on each of the engine units, its tractive force at 85 per cent. of the boiler pressure reaches the exceptionally high value of 72,940 lb. The driving wheels are 4 ft. 8 in. in diameter, the engine being intended largely for use for banking work on the steepest gradients on the system. The arrangement of the cylinders and valve gear practically duplicates that of the Gresley 2-8-0 type engines on the Great Northern section of the railway. Details of the gear were given in our issue of April 25, 1924. The valve gear is of the Walschaert type for the outside cylinders, the motion of these two gears being combined by the Gresley system of levers to drive the third and inside valve. The leading unit carries a water tank of 2,800 gallons capacity, and the rear unit a tank of 2,200 gallons capacity, together with a coal bunker of 7 tons capacity. The boiler is of the round topped type, the dimensions greatly exceeding

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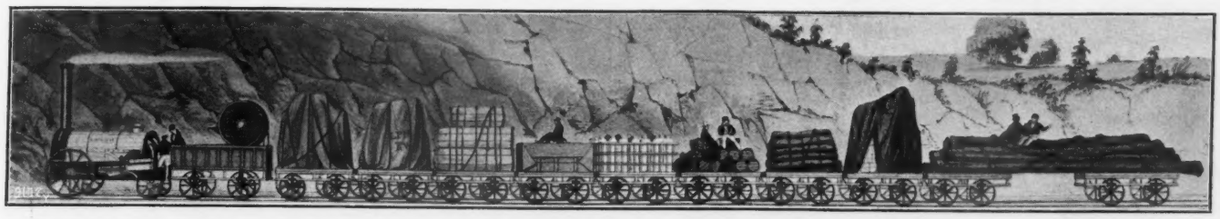

FIG. 45.

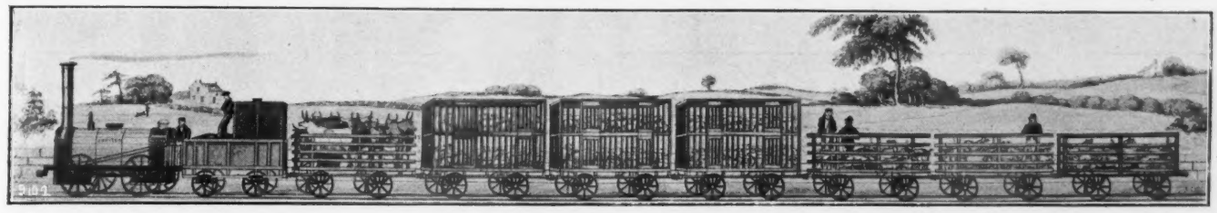

FIG. 46.

FIGS. 45 AND 46. TRAINS ON THE LIVERPOOL AND MANCHESTER RAILWAY; FROM AN ENGRAVING OF 1834.

FIG. 47. FIRST-CLASS PASSENGER COACH; STOCKTON AND DARLINGTON RAILWAY, 1825.

FIG. 48. THIRD-CLASS PASSENGER COACH, 1840.

anything previously obtaining in Great Britain. The outside diameter is 7 ft., and the length from the front tube sheet to the back head is 22 ft. 4 in. Previous Garratt locomotives have been very free steamers, due in great measure to the large capacity of the fire-box which is possible in this type of construction, and this characteristic is fully retained in the present model. The smoke-box is cylindrical, and contains a Robinson type superheater header having 45 elements. The heating surface of the boiler tubes is 2,757 sq. ft., of the fire-box 237 sq. ft., giving a total of 2 994 sq. ft. The superheating surface is 646 sq. ft. The grate area is 56·4 sq. ft. The total wheelbase is 79 ft. 1 in., but the adoption of the Garratt principle makes it possible for the engine to take a curve of 5 chains. It will thus enter yards which would be inaccessible to much smaller locomotives of normal type. We propose to deal with the engine in detail in our next issue.

Another interesting locomotive has just been turned out of the Doncaster shops to the designs of Mr. H. N. Gresley for the London and North-Eastern Railway, and is illustrated in Fig. 44. This is the first 2-8-2 (Mikado) type locomotive to make its appearance on the railways of this country, and is the most powerful freight engine on our lines apart from the Garratt just described. The total weight of the engine and tender work out at 151 tons 8 cwt. in working order. With over 72 tons on the driving wheels the engine is capable of exerting a tractive effort of no less than 38,500 lb., and being fitted with a booster this can be increased up to 47,000 lb. The load on the booster axle is 18 tons 4 cwt. The engine has three cylinders, each 20 in. in diameter, with a stroke of 26 in. The booster has two cylinders, 10 in. by 12 in. The leading wheels are 3 ft. 2 in. and the trailing 3 ft. 8 in., while the drivers are 5 ft. 2 in. in diameter. A prominent feature of the locomotive is the large boiler which has a total heating surface of 2,930 sq. ft., with, in addition, superheating surface of 525 sq. ft. The heating surface is made up of 215 sq. ft. in the wide fire-box, 1,880 sq. ft. for the 168 tubes $2\frac{1}{4}$ in. in diameter and 19 ft. long, and 835 sq. ft. for the superheater element flues $5\frac{1}{4}$ in. in diameter. The grate has a width of 6 ft. $11\frac{3}{4}$ in. and a length on the slope of 5 ft. $10\frac{11}{16}$ in. The area thus provided is 41·25 sq. ft. The fire-box tube sheet is set into the barrel providing extra combustion space for the box. The front ring of the barrel is 5 ft. 9 in. in diameter inside; the second ring tapers out to a diameter of 6 ft. 5 in. at the throat sheet end. The working pressure is 180 lb. per square inch. The total wheel base of the engine is 36 ft. 2 in., the driving wheel base being 18 ft. 6 in. The tender carries 7 tons of coal and 4,700 gallons of water. The wheel base of engine and tender is 59 ft. 8 in. and length over buffers 69 ft. 10 in. Mr. Gresley has thus celebrated the year of the Centenary by turning out two quite interesting and unusual locomotives.

Considerations of space make it impossible to follow the progress of locomotive building in

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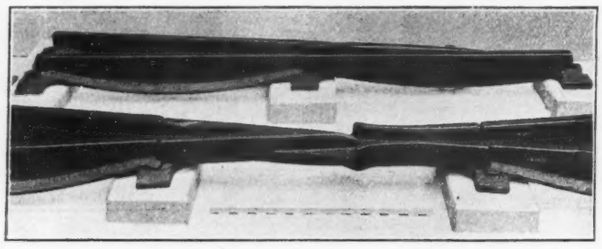

FIG. 49. EDGE RAIL OF 1793.

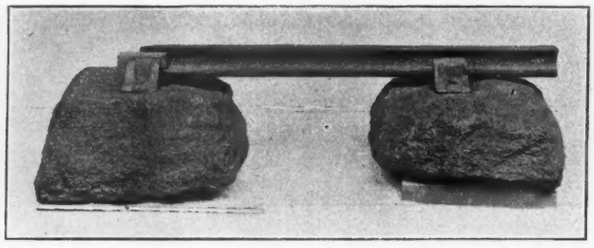

FIG. 51. PERMANENT WAY OF 1834.

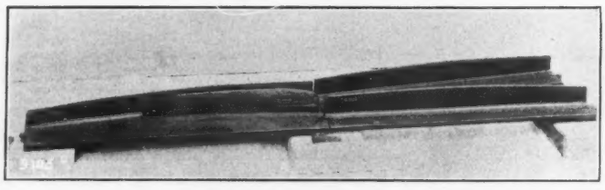

FIG. 50. PLATE WAY OF 1799.

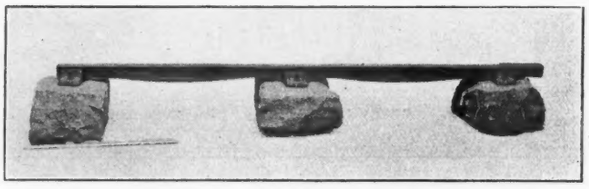

FIG. 52. FISHBELLIED RAIL, 1825.

constructional detail and individual parts. From the time when expansion was put on a good working footing by Howe's link, of which Fig. 27, page 789, shows the original wooden model, the history of that important part of locomotive gear is familiar. The most notable feature of it is perhaps the considerable time that the Walschaert's gear, invented in 1844, and practically perfected in 1848, had to wait before it received the recognition it enjoys to-day.

The evolution of carriages has produced results which have changed appearances even more than in the case of locomotives. Without following the stages it may be interesting to refer to a few examples of the early accommodation provided. The first passenger carriage ever used on a railway is shown in Fig. 47. Made in 1825, for the Stockton and Darlington Railway, until 1833 it was usually or always horse drawn, the steam engine being reserved for coal trucks. Figs. 45 and 46 show from a contemporary print how early steam trains were made up. The line, so far as it entertained passengers, cared little for any but first class, and the third-class carriages were merely open wagons without seats; the best that can be said for them is that they had a hole in the floor to carry off the rain. Fig. 48 represents a third-class carriage built about 1840 for the Bodmin and Wadebridge Railway; perhaps the most remarkable fact about it is that it was used on that line until 1889. Its construction may be understood without difficulty. It weighed 2·91 tons, and had a wheel base of 6¾ ft. By 1848 Mr. R. C. Mansell introduced his wheel for passenger carriages. This remains practically the same to this day.

The development of the permanent way of railways, though intrinsically a much simpler business than that of locomotives, appears for some time to have proceeded no faster than the more complicated work. For this there seem to be two probable reasons. There are a number of engines on a busy line even of moderate extent, and the use of one for a short while may produce fresh information; but there is only one permanent way, and experiments thereon require much time. The laying of railways, again, was not a new art, like the running of locomotives. Since some date earlier than 1600, railways or tramways had been in use regularly in mining districts. The track had acquired its own characteristics, developed with regard to the much lighter loads and lower speeds possible with horse traction; and though doubtless those who were in charge of it would be aware that roads to carry locomotives and their freight were more exacting than when the load was limited by the strength of a horse or horses, even the wisest of them failed to realise how much more resistance the road required. As the development of locomotives shows, they did not even know from one decade to another how much heavier and faster the locomotives themselves would be. Nevertheless, the matter was one of perhaps greater consequence to railway pioneers than seems always to have been recognised. The comparative frequency with which locomotives were derailed may have been due to their particular features; but sometimes it seems quite as likely that the road was at fault. The steps therefore by which the early railroads came to improve themselves are a part, and may have been a very important part, of the means by which railway transport succeeded in making progress.

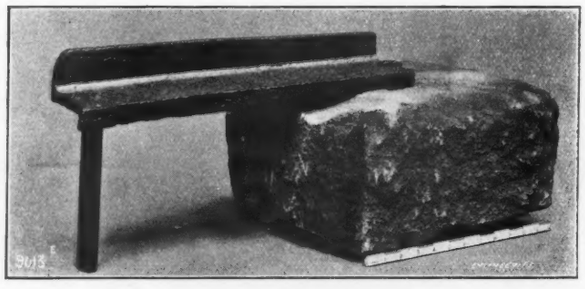

FIG. 53. SURREY RAIL AND SLEEPER, 1801.

Passing by the early days when rails were longitudinal timbers, which in the next stage were furnished with wooden facings that could be renewed when sufficiently worn, and the cast-iron facings to them that were substituted at Coalbrookdale in 1767, the first step to iron railroads was made by a cast-iron plateway laid at Sheffield in 1776, with a raised flange, which kept wagons on the track, and also dirt. Then came cast-iron edge rails, an example of which, taken from a line laid in 1793 and still in use, is represented in Fig. 49. They were spiked to plugs in stone at a gauge of 4 ft. 4⅝ in., and the switch that moved the point at the crossing turned on a pin dropped into a hole, and had to be operated by hand. The plateway from which the specimen represented in Fig. 50 was taken was laid in 1799, and is still occasionally used. Here again the switch, though it has a wrought-iron tongue, has to be moved by hand. The edge rails were cast with feet, which broke off, and this in 1797 led to the invention of chairs. Wrought iron was introduced first in 1808 as a square bar, with spikes driven through it into wooden plugs in stones, though its cost resulted in cast-iron being continued in use, and the fish-belly section to be introduced as a means of strengthening the rail. Fig. 53 is from a piece of plate rail of the Surrey Iron Railway begun in 1801, the rails being secured on a double road at about 4·7 ft. gauge. One form of it was the rack with half-round depressions along the side that accommodated the driving spur wheel of Blenkinsop's 1812 locomotive. By 1820 rolled-iron rails began to come in, successively with single head and in fish-belly section; the latter ingeniously managed by a groove of varying section in the bottom roll and a second pass on the flat through plain rolls. A piece of the Stockton and Darlington road is represented in Fig. 52, the rails being pinned to the chairs and the chairs secured to stone blocks by wooden pegs. The Liverpool and Manchester road had heavier rails with larger chairs, in which they were fixed with side keys. By 1834 the Bodmin and Wadebridge Railway had a permanent way of standard gauge with granite-block sleepers about 20 in. square by 12 in. deep, and with transverse blocks 6 ft. long at intervals to act as ties. Cast-iron chairs were spiked into holes in the sleeper plugged with wood. The rails, 42 lb. per yard, were of wrought iron, 3½ in. deep, and of something like a bull-headed form. Fig. 51 shows a piece taken from it.

The signalling arrangements had their origin in simple beginnings, and perhaps the most remarkable fact about them is that the semaphore was introduced by Sir Charles Hutton Gregory in 1841, and remains still the almost universal basis of mechanical signals. The electric telegraph followed very quickly on the introduction of railways, and by 1844-5 Sir W. F. Cooke's block system was tried in the comparatively complicated form shown in Fig. 56, in which each station had a signal of the

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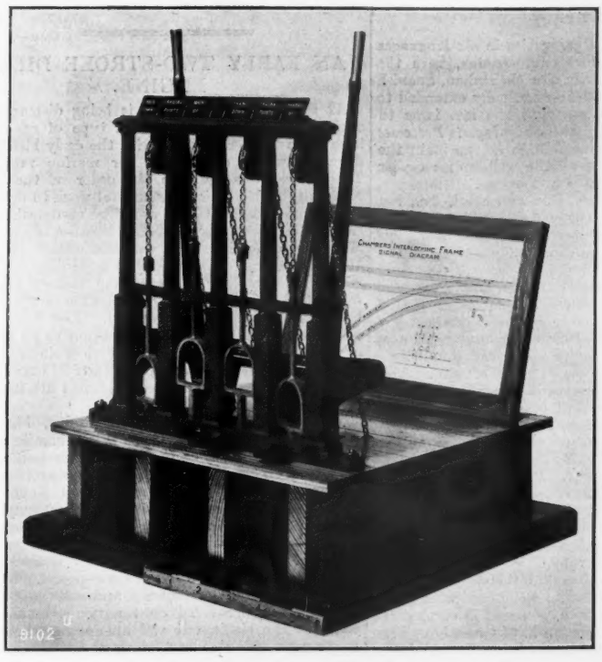


FIG. 54. CHAMBERS' INTERLOCKING FRAME, 1860.

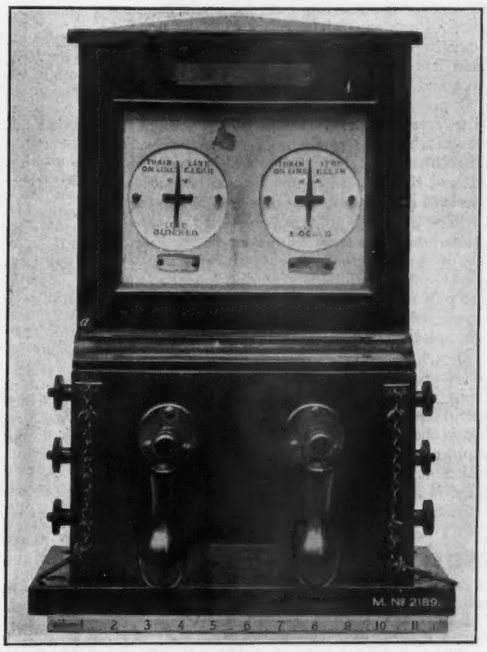


FIG. 55. CLARK'S BLOCK SIGNAL INSTRUMENT, 1854.

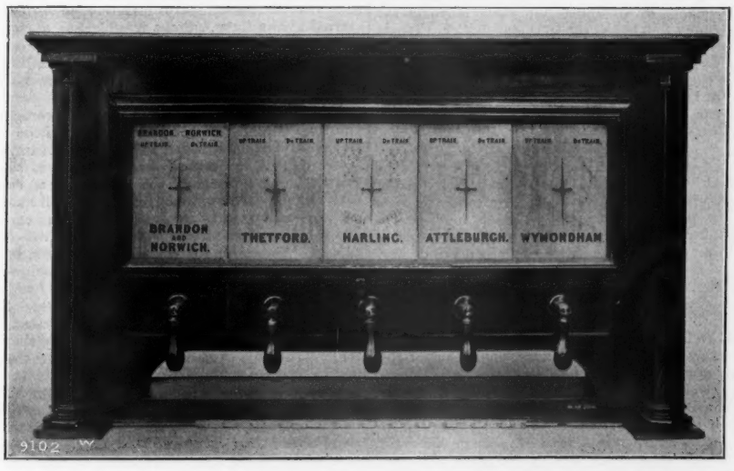


FIG. 56. BLOCK SIGNAL INSTRUMENT, 1844.

situation at every other station. By 1854 E. Clark had simplified the method to the form shown in Fig. 55, with two needles indicating by their position whether the line was blocked or clear. In 1856 Saxby connected the point and signal levers, so that they worked simultaneously, but it was not till 1860 that Chambers produced the interlocking frame, in which each lever moves independently, but is controlled by the previous movement of the point or conflicting signal levers.

The brief summary given above describes the manner in which famous railwaymen have solved the problems of their times. The recital inevitably suggests the problems that remain for attention in the present and the future. There is still, and must always be, the investigation of new methods, designs and materials, which formed the majority of the problems that arose when the industry was new. In the definition, for example, of the circumstances in which electricity may be applied with advantage to railway traction an old problem arises in a new form, and railways have again to weigh the circumstances in which power generated by stationary engines may be more advantageous for traction than when generated on a locomotive. A hundred years ago the question was a burning one, and the locomotive service began to be possible only when, in most circumstances, the question was answered decidedly against the stationary engine. With electric generation the answer is by no means so decided. Already conclusive evidence has shown that in some circumstances the stationary generation of power and its conversion into current may give a more efficient and flexible service than can be obtained by locomotive generation, but the evidence is not yet sufficient to permit of any general statement of when such generation and conversion will be economically advantageous. The gain that has been shown where the method is properly applicable is so large that this is certainly one of the great questions of the immediate future, and with it goes the problem, analogous to the battle of the gauges, of deciding the form in which current is most efficient for the particular purposes of the railway service. The difficulty of all such problems is that they can only be decided on circumstances as they now are and can be foreseen, and the decision cannot provide for the circumstances that cannot be foreseen. In the question of electric traction, for instance, the comparison to-day must be between locomotive generation of power that falls far short of what is theoretically possible, and stationary generation, that gets much nearer to it. The problem of improving the efficiency with which fuel is used to generate power affects other industries besides railways, but to railway work it is of capital importance. The metals, again, of which railway appliances can be made are theoretically far more numerous than they were, but for many purposes the most attractive of them are excluded by their cost. Problems of this kind affect all industries, and the railway service has learned by experience and knows by well-established tradition, how far-reaching may be the consequences of an ill-considered change, and, on the other hand, how grievous those of a lost opportunity.

But beyond the problems that involve the discovery, criticism and application of methods and materials that are new, the railway service to-day is concerned still more to make the most of what it already has. Its great roads and structures impose on it quite definite limitations, which when the industry and profession of railway engineering were new, left a good working margin. Little of that margin remains, and perhaps many of the problems that are of most interest to it to-day arise from the fact that some of the most important of the resources can look in practice to little or no extension, while the demands made are almost certain to increase. Some of the solutions may be helped by scientific inquiry. In the very earliest days of steam railways man recognised that the resistance of the air to a moving train might be something considerable, but in spite of wind tunnels and aerodynamical theory, the railway service has not advanced to any great extent in taking practical account of this resistance, or even in making its selection from the fifty odd formulæ that have been proposed for determining the resistance. A great amount of work, again, has been done in India, America and elsewhere on the

effect of moving loads on bridges. For the time being the best result that can be announced is that the whole matter needs further investigation, and though by using great factors of safety, bridges are made safe against the moving loads to which they are subject, no one can tell whether the safe live load on existing bridges may not be a good deal higher than has been calculated, or whether new bridges to stand given live loads need be as heavy as must at present be assumed.

The railway service provides the main arteries and veins through which the products of industry flow. Its traffic returns have long been held to be the safest index of the state of commerce, as the pulse is of the human circulation. Those who administer it have a hard and difficult task, especially at the present time, and it is none the easier because of the gravity of the issues that depend on its efficiency. The present Centenary should be an encouragement to them to remember that the pioneers whose work is now being celebrated left behind them more than their splendid works. Their spirit of indefatigable keenness, combined with sound judgment, is the fortunate inheritance of their successors to-day.

In concluding this article we would like to acknowledge the assistance we have received in its preparation, and in facilities connected with the reproduction of many of our illustrations, from the Science Museum, South Kensington, and also from the Institution of Mechanical Engineers.

NOTES ON NEW BOOKS.

THERE are many types of industrial work in which it is essential to have a handy means of obtaining information relating to the humidity of the atmosphere. In the textile trades, as is well known, the effect of the humidity of the air is markedly reflected in the product of the factories, and regulations have been framed to fix the limits which it is permissible to use. There are other phases of work in which the moisture content of the air has an important bearing on the work done, such as in the tobacco and tea trades, and, indeed, in every case in which drying must be resorted to. We now have available "*Practical Humidity Tables*," which were compiled by the technical staff of Messrs. A. B. Cleworth and Co., Limited, who specialise in matters relating to air conditioning. These tables are put up in serviceable form and published by Messrs. Taylor and Francis, of Red Lion Court, Fleet-street, London, at a price of 6*s*. net. The data on which the tables have been based are the well-known "Hydrometical Tables" of Professor Glaisher, and will be found to meet the requirements of practical work in the same way as those of Professor Glaisher are suitable for use for scientific purposes. In range they cover the requirements in the various industries in which temperatures between those of refrigeration and the boiling point of water at atmospheric pressure are used. There are sets of tables for Centigrade and Fahrenheit, and for wet and dry bulb thermometer readings, and we are satisfied that the compilers have given the necessary information in a form which will be greatly appreciated by all who are concerned with such matters in industry.

The Association of Engineering and Shipbuilding Draughtsmen has recently added to its valuable series of publications two useful pamphlets. Of these, one dealing with "*The Design of Marine Diesel Engines*" has been prepared by Mr. A. Buchanan. In this the author deals comprehensively with the proportioning of Diesel engine details, and his work will undoubtedly prove extremely welcome to the many draughtsmen who have now to take an interest in "Diesel" engineering. We note one minor slip, where it is stated that "for a given volume of cylinder the cylindrical surface is a maximum when the length of the cylinder is equal to the diameter." The word maximum should, of course, be replaced by minimum. This unlucky oversight is not likely to mislead anyone, and in no way detracts from the great utility of the pamphlet considered as a whole. The second pamphlet deals with "*The Balancing of Reciprocating Engines*." It has been written by Mr. G. A. Stephens, and discusses in detail the problems most commonly encountered in practice. To illustrate the use of the formulæ arrived at the author works out in detail the balancing weights for a two-cylinder locomotive. In our issue of December 9, 1921, Mr. P. Cormack showed how greatly balancing problems could be simplified by the use of an exponential analysis. Unfortunately, few draughtsmen are familiar with the exponential forms of the circular functions, so that Mr. Stephens was probably wise to base his treatment of the subject on the familiar sine and cosine functions. Both pamphlets are on sale at the offices of the Association, 96, St. George's-square, London, S.W.1, the published price of each being 2*s*.

The series of technical dictionaries in six languages edited by Mr. Alfred Schlomann, Munich, with the assistance of German, British, French, Italian, Spanish and Russian specialists, is being gradually extended to cover every branch of industry. The last issue to reach us is Vol. XV, dealing with *Spinning, its Processes and Products*. This volume follows in the main the principle which obtains in all the well-known earlier volumes, dealing with Steam Engines, Electricity, Railways, the Metallurgy of Iron and Steel, &c., but it measures 9 in. by 6¼ in., instead of 7 in. by 4 in., the size of the earlier issues. For this class of book, this constitutes an improvement; one or two of the earlier volumes of the smaller size, had, by reason of the complexity of the subjects treated, too great a number of pages and were rather unwieldy. The larger size of Vol. XV has made it possible to produce a dictionary of reasonable thickness and also to give illustrations of spinning machinery to a larger scale than would have been possible with the former smaller size. This latter condition enables the various component parts of the different machines, all of which are carefully marked with reference letters, to be clearly seen. We say this in no disparagement of the similar outline illustrations in the earlier smaller sized volumes, all of which are exceedingly neat. Vol. XV deals with the preparation, spinning and other operations and processes which every form of textile fibre has to undergo previous to weaving. It is divided into sections covering the preparation and the spinning of cotton, coarse cotton yarns, flax, hemp, jute, ramie, wool, worsted, silk, asbestos, &c., rope making, and all the work, machines and apparatus relating thereto. The care with which the present volume has been prepared is emphasized by the fact that the Catalonian local terms have been added to the Spanish, Catalonia being the chief seat of the Spanish textile industry. The work contains 616 pages of illustrated reference matter in seven languages, counting the Catalonian dialect, and 335 pages of indexes. There is a separate index for each language, which is a further improvement upon the earlier volumes; in these, the German, British, French, Italian and Spanish terms were grouped together, the Russian terms only being indexed apart. Vol. XV is issued at the price of 41*s*. net by Messrs. Lewenz and Wilkinson, Limited, 25, Victoria Street, London, S.W. Mr. Lewenz has been appointed editor and manager for the British section of this series of dictionaries.

In these days as much as is possible is rarely done to interest the staffs and workpeople of industrial organisations in the history of the firms and the parts they have played in progress. This is much to be regretted, for a greater appreciation of, and pride of association with, the pioneers of engineering may serve a very useful purpose in the associations of industrial life. A small book entitled "*The History of Bryan Donkin and Company*," by Mr. Harry J. Donkin, M.I.Mech.E., indicates that some of our older organisations have a history of which every member or employee should be proud. In its few pages, the author of this work has given sufficient information to create a desire for more, which we trust that he will be able to gratify. The firm of Bryan Donkin and Company was founded in 1803 by Bryan Donkin, who was a Vice-President of the Royal Society. He was a man of strong character, who, against the early wishes of his parents, forsook the calling the family was interested in and followed his mechanical inclinations. That he was a versatile and prolific inventor is manifest from the brief statement of his work in this volume. We think there is every possibility that there are records in the keeping of the members of his family, who are his successors, of the relationships between him and John Hall, the father of the founders of Messrs. J. and E. Hall, Limited, of Dartford, of Richard Trevethick, Humphreys and Bertrams, and other pioneer engineers who were associated with him in early days. His relationships with Smeaton; with Louis Robert, the inventor of the paper-making machine put before the world by the Fourdrinier brothers, for whom Donkin actually made the machines; with Bacon, with whom he patented what was probably the first successful rotary printing machine; with Appert, whose work on food preservation he carried to success; these must all be of great interest. There is a hint of the existence of correspondence between Bryan Donkin and Telford, Rennie, Bramah, Boulton and Watt, Murdock, Simpson, Maudslay, Congreve, the two Brunels and Nasmyth, and of diaries containing entries which the engineering public would gladly hear more of. It was three of Bryan Donkin's pupils, Palmer, Harris and Ashwell, who started a small club for the discussion of engineering matters, from which later was founded the Institution of Civil Engineers. Need we say more to show why we are desirous that, no matter how well Mr. Harry J. Donkin has done his work for this publication, he will be encouraged to extend and amplify the references and give us a much longer work.

AN EARLY TWO-STROKE DIESEL ENGINE.

AT the present time there is being dismantled an engine of the two-stroke Diesel type of exceptional interest to those concerned with the early history and development of oil engines for marine propulsion. This engine was built to the order of the British Admiralty in 1911 for experimental work to determine whether it was feasible to use large two-stroke Diesel engines for warship propulsion. Because of the nature of this investigation little was said about the engine at the time, and, consequently, it is possible that those who are interested in engineering history may lose sight of a very valuable contribution made by the builders, Messrs. Vickers Limited. Lest that should be the case, we wish to call attention to its size, for it was the largest Diesel-engine with a single cylinder at the time of its construction. The fuel consumption and the high mean indicated pressures attained in it are also worthy of comment.

With the consent of the Admiralty, Sir James McKechnie made a reference to this engine in a paper on "Internal-Combustion Engines with Large Cylinders," which he read at the Engineering Conference organised by the Institution of Civil Engineers in 1921, and this was reprinted in ENGINEERING, vol. cxii, page 132. The cylinder diameter of this single-cylinder, single-acting two-stroke engine was 30 in., and the stroke of the piston was 36 in. With it the designed power was to be 1,000 brake horse-power. It was of the type having a crosshead and astern guide, the surfaces being provided on the two columns of the engine. The piston was of built-up construction, the upper part being of cast steel, cooled internally by means of water led to and from the piston through the hollow piston rod, to which were attached sliding pipes communicating with the pressure and discharge chambers of the water-cooling system. The connecting rod was of the ordinary forked type with brasses carried in the forks. Some trouble was at first experienced owing to heating of these connecting-rod bearings, but this was eventually overcome by a novel system of oilways without using particularly high lubricating pressures.

The inboard and outboard columns were separate and were of cast steel bolted to the base of the cylinder and to the bedplate, which was of the ordinary warship type adapted to rest on seatings built in the ship.

As originally designed the cover was of cast steel with the bottom cast into it. It is now well known that such covers are apt to crack under high load conditions, and this happened after some time in this experimental engine. A cure for the trouble was effected by fitting a forged-steel plate 2 in. thick, on the lower face, which was bossed up to 3 in. thick in way of the scavenge valves. This construction, which proved completely successful, was patented by Messrs. Vickers Limited, and has since 1912 been used by them in all their high-duty work and for their larger mercantile marine engines. Trouble was also experienced owing to the heat stresses in the upper part of the liner, especially at the indicator hole. This was overcome by the introduction of special means of water circulation beside this part of the liner, and no later trouble was observed. Scavenging in this engine was effected by the use of four water-cooled valves in the cover, the air being delivered by means of a motor-driven centrifugal blower.

Once the difficulties referred to were completely overcome, official trials were run in 1913. The first trials lasted ten days and included more than 100 hours on full load, during which time 1,050 brake horse-power, at 140 r.p.m. were developed on a consumption of 0·40 lb. of fuel per brake horse-power per hour, a most remarkable figure for the time, and one which, even now, would be regarded as quite noteworthy. The mean indicated pressure obtained from the cards with this engine was 122·5 lb. per square inch with air injection. Considerable trouble was experienced with the air compressors, although they were running at relatively low speed and frequent changes from one compressor to another had to be carried out. Subsequently trials with solid injection were put in hand, the air injection fittings being used, as far as possible, and promising results were secured, mean indicated pressures up to 125 lb. per square inch, being obtained. Fuels of various descriptions were used, some of them being of a very asphaltic character. Circumstances prevented these later trials being carried to a conclusion, but it was found after lengthy running that asphaltic deposits were left in the engine, both with air and solid injection, and with the ordinary arrange-

ment of sprayer, valve troubles might eventually arise due to accumulations of deposit on the spraying nozzles. It is interesting to note that the nozzle used with air injection consisted of a round cap below the spray valve with several large holes in it, thus dividing the charge of pulverised fuel into several jets, this being on the lines subsequently adopted in the German submarine engines handed over to this country at the Armistice. That the results mentioned were obtained at so early a period by Messrs. Vickers Limited, is certainly worthy of record. This engine has now completely served the purpose of its construction for experimental work and it has been demolished.

The outbreak of the European war, and the consequent call for submarine engines from Barrow-in-Furness, prevented the development of this type of engine for commercial use, and on the cessation of hostilities the firm, as far as commercial Diesel engines were concerned, concentrated upon engines of smaller power for which there was an existing demand. In such cases, four-stroke engines were usually offered, but for powerful direct-driven installations of moderate speed the two-stroke engine offers a good solution, and the experience gained in the construction of this early experimental engine will prove of undoubted value in deciding upon their design.

THE OPTICAL SOCIETY.

AT a meeting of the Optical Society held on Thursday, the 11th inst., resolutions were adopted reducing the annual subscriptions of Fellows and Members to 2*l.* 2*s.* and 1*l.* 1*s.*, respectively, and abolishing the entrance fees for all classes of membership. These reductions will become effective on January 1 next. The President explained that the Council had decided to make these reductions in the hope that the membership of the Society would be increased by the entrance into it of a large number of the members of the ophthalmic section of the profession and of the junior workers in all branches.

A paper by Mr. E. F. Fincham on "*The Changes in the Form of the Crystalline Lens in Accommodation*" was read and discussed. The two most important existing theories of the mechanism of the accommodation of the eye are directly opposed in that they assign differently the effect of the ciliary muscle in the production of the change in the form of the crystalline lens. The theory of Helmholtz, which is the more universally accepted, states that the lens swells and increases in convexity during accommodation because the tension upon it is relaxed when the ciliary muscle contracts. In order to explain the change of the anterior surface of the lens to a hyperbolic form in accommodation, Tscherning has propounded a theory in which the tension of the lens is maintained when the muscle contracts, and the forms of the surfaces are altered by a pressure by the vitreous humour exerted upon the periphery of the posterior lens surface.

This paper describes the measurement of the radii of curvature of both anterior and posterior surfaces of the lens, and also the movement which the apices of these surfaces make in accommodation. In two selected cases of men of the same age and having the same refractive error, considerable differences in the behaviour of the lens in accommodation were found. The results show that, for a given amount of accommodation, whereas the lens surfaces in one case are more increased in curvature than in the other, their apices suffer less movement. It was also found that the surface which was most altered in curvature showed the most pronounced hyperbolic form in both relaxed and accommodated conditions.

A paper on "*The Optical Properties of Amethyst Quartz*," by Professor C. V. Raman, F.R.S. and K. Banerji, of Calcutta University, was read in abstract. A section-plate of amethyst cut normal to the optic axis, when viewed under suitable conditions without a polariser or analyser, shows coloured diffraction fringes of the Fresnel type, arranged periodically and running parallel to the lines of the structure. The diffraction effect is due to the periodic change of phase produced by the structure and not to any periodic variation of transparency. The diffraction spectra of the Fraunhofer type due to the structure may also be observed. Since a section-plate of amethyst quartz is thus in effect a phase-change diffraction grating, its appearance in the polariscope may be interpreted in the light of the Abbé theory of microscopic vision, and in fact furnished very convenient illustrations of that theory.

Dr. R. S. Clay and Mr. Thomas H. Court exhibited a lucernal microscope by Samuel Washbourn, London. The instrument, which was probably made in 1800, is provided with adjustments for focusing and for moving the object in two directions at right angles to one another. The objectives, consisting of single lenses, are mounted in a vertical slide so that different powers may be used. All the adjustments can be made from the eyepiece end. The instrument can readily be taken to pieces and the parts fit into a case.

LETTERS TO THE EDITOR.

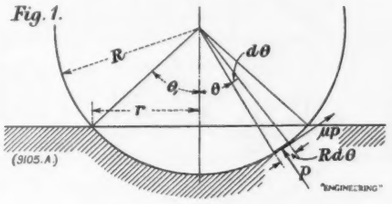
FRICTION EFFECT IN BALL HARDNESS TESTS.

TO THE EDITOR OF ENGINEERING.

SIR,—In a paper recently read before the Institution of Mechanical Engineers by Mr. Hankins, and reprinted in your issue of May 1, on the effects of adhesion between the indenting tool and the material in ball and cone indentation hardness tests, for simplicity of treatment the assumption was made that the intensity of pressure between the ball and the specimen is constant over the surface of the indentation.

This assumption is probably very far from the truth, and a correction for friction based on it may be considerably in error. It is, however, possible to avoid any assumption regarding the distribution of pressure or the value of the coefficient of friction by the following method :—

Fig. 1.



Using Mr. Hankin's nomenclature and definitions and referring to Fig. 1 :—

Let p = normal pressure per unit area between ball and material.
P = total load applied to ball.
P_f = that portion of the total load supported by friction between the surface of the ball and the specimen.
r = half the diameter of the impression.
R = radius of the ball.
$\theta_1 = \frac{1}{2}$ angle of the impression $= \sin^{-1}\frac{r}{R}$.
μp = tangential force of friction per unit surface area.

The portion of the load carried by friction on an elemental ring

$= \text{vertical component of } \mu p \times \text{area of ring.}$
$= \mu p \sin\theta \times 2\pi R^2 \sin\theta\, d\theta.$
$= 2\pi R^2 \mu p \sin^2\theta\, d\theta.$

$$P_f = 2\pi R^2 \mu \int_0^{\theta_1} p \sin^2\theta\, d\theta \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now let the ball be rotated about an axis perpendicular to the surface of the specimen.

Torque required to overcome friction on an elemental ring

$= \text{force of friction} \times \text{radius of ring.}$
$= \mu p\, 2\pi R^2 \sin\theta\, d\theta \times R \sin\theta.$
$= 2\pi R^3 \mu p \sin^2\theta\, d\theta.$

Total torque required

$$T = 2\pi R^3 \mu \int_0^{\theta_1} p \sin^2\theta\, d\theta$$

or

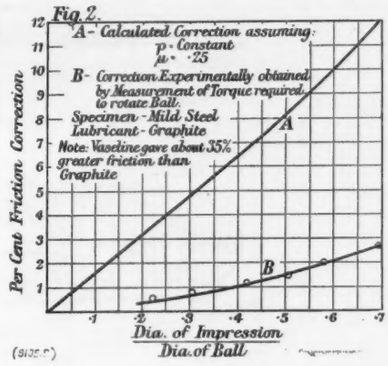
$$\int_0^{\theta_1} p \sin^2\theta\, d\theta = \frac{T}{2\pi R^3 \mu} \quad . \quad . \quad (2)$$

Substitute (2) in (1).
Then

$$P_f = \frac{T}{R}$$

Thus it is seen that in order to arrive at the mean corrected contact pressure it is only necessary to measure the torque required to rotate the ball between two similar specimens and divide by 2 to obtain T.

Fig. 2.


A- Calculated Correction assuming: p - Constant μ = ·25
B- Correction Experimentally obtained by Measurement of Torque required to rotate Ball.
Specimen - Mild Steel
Lubricant - Graphite
Note: Vaseline gave about 35% greater friction than Graphite
A
B
Per Cent Friction Correction
Dia. of Impression / Dia. of Ball
(9105.F)

TESTS WITH 1-IN. BALL ON MILD STEEL—LUBRICATED WITH GRAPHITE.

I	II	III	IV	V	VI	VII	VIII	IX	X
P Tons.	Equivalent Load on 10 mm. Ball. Kg.	Diameter of Impression. ÷ Dia. of Ball.	Torque to Cause Rotation of Ball. Inch-lb.	$\frac{T}{R}$ Tons.	$\frac{T}{R\,P} \times 100$ Correction. Per cent.	Contact Pressure Kg./mm.²	Corrected Contact Pressure Kg./mm.²	Corrected Contact Pressure by Mr. Hankins' Method $\mu = 0{\cdot}25$.	Correction Necessary to obtain Figure in Col. IX. Per cent.
2·5	394	0·225	30	0·013	0·5	99·2	98·7	95·6	3·6
2·5									
5	790	0·306	88	0·039	0·75	108	107·2	102·7	4·9
5									
10	1,580	0·419	258	0·115	1·15	114·3	113·0	106·7	6·7
10									
15	2,360	0·507	490	0·219	1·46	117	115·3	107·4	8·2
15									
20	3,150	0·581	900	0·402	2·0	119·5	117·1	108	9·6
20									
30	4,730	0·695	1,800	0·805	2·7	124·5	121·1	109·6	12·0
30									

Then if P is the total load on the ball, $P - P_f$ is the net load carried by the specimen, *i.e.*, excluding the effect of surface friction, or corrected contact pressure

$$= \frac{P - P_f}{\text{projected area of indentation}}$$

$$= \frac{P - \frac{T}{R}}{\text{projected area of indentation}}$$

In order to test this method, a series of experiments was made and the results are shown in the accompanying table; in this the upper sets of figures for each loading relate to tests in which the ball was not rotated. Columns I to V are self-explanatory. Column VI is the friction correction obtained by the method just described. Column VII gives the hardness numbers determined in the usual manner, but calculated on the basis of projected area indentation. Column VIII gives the hardness number after applying the correction in Column VI. Column IX gives the corrected contact pressure and Column X the friction correction, both calculated by the method described by Mr. Hankins.

A comparison of Columns VI and X shows a wide discrepancy. This is illustrated by the curves in Fig. 2.

The results obtained by the method here advocated have been approximately confirmed by comparing the diameter of the indentation made in the ordinary way with that made by a ball rotated under load. As was expected, the latter indentation was slightly larger due to the fact that the rotation of the ball destroys the supporting effect of friction. The load, when divided by the projected area of the larger indentation, gives a "corrected contact pressure" which agrees very well with those in Column VIII of the table. Accurate confirmation by such comparison

GEARED-TURBINE PADDLE BOATS.

Fig. 1.

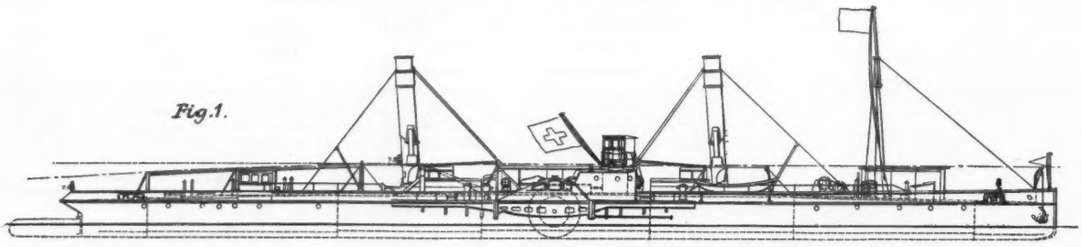


Fig. 2.

Length between P.P	*65*	*M*	*213'0"*
Breadth over Frames.	*8*	*,*	*26'3"*
Depth Moulded.	*2·80*	*,*	*9'2"*
Draught	*1*	*,*	*3'3"*

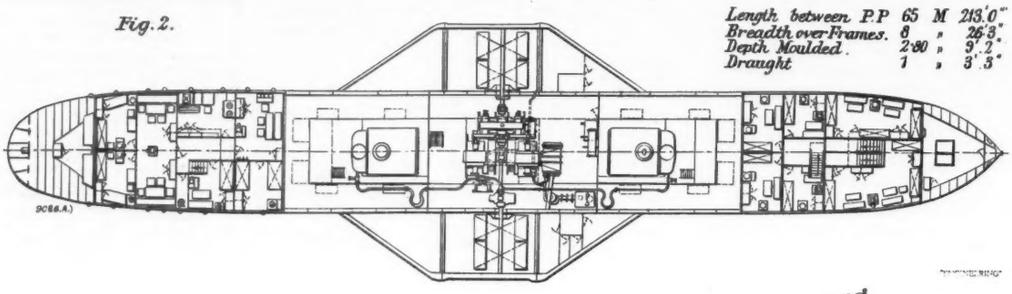


Fig. 3.

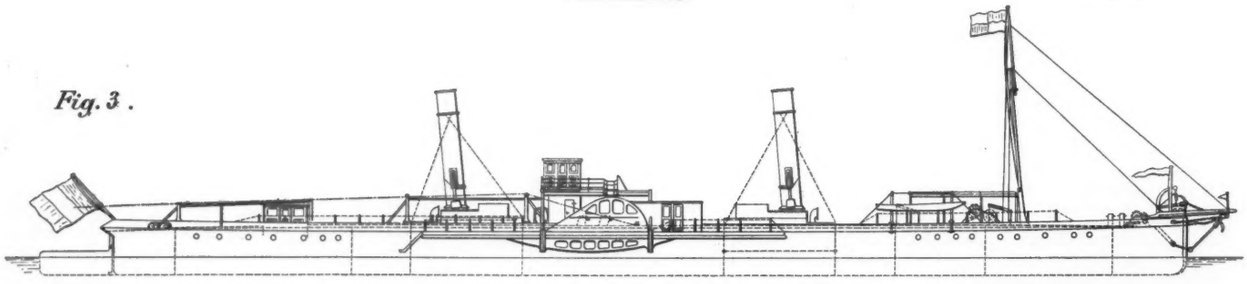
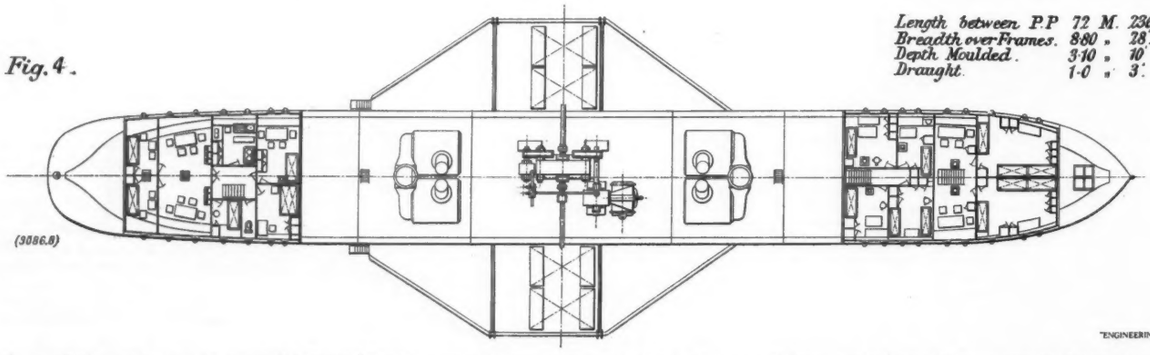


Fig. 4.

Length between P.P	*72*	*M.*	*236'0"*
Breadth over Frames.	*8·80*	*,*	*28'10½"*
Depth Moulded.	*3·10*	*,*	*10'2"*
Draught.	*1·0*	*,*	*3'3"*



"ENGINEERING"

is difficult to obtain, owing to the small differences in the diameters involved, and to the difficulty in preventing seizure between the ball and the specimen when rotated to any extent under load.

In short, without assuming any value for the co-efficient of friction between the ball and its indentation, without assuming any particular stress distribution, and with practically no calculation, the friction correction may be obtained by dividing the torque required to start rotation of the ball under load by the radius of the ball. This figure, when subtracted from the applied load, gives the net load supported by the specimen.

Yours faithfully,

H. G. CAMPBELL.
C. M. WHITE.

Engineering Department, King's College,
London, W.C. 2, June 15, 1925.

GEARED-TURBINE PADDLE BOATS.

TO THE EDITOR OF ENGINEERING.

SIR,—With reference to the article published in your journal on March 20, 1925, we note that, on page 361, reference was made to the paddle boat Dortrecht as being the *first* geared-turbine paddle boat which has as yet been built. This statement, we think, is not quite correct, and we beg to place before you the following true state of affairs concerning this subject.

The actual first geared-turbine paddle tug, the Zürich, was built three years ago by Escher Wyss and Co., S.A., Zürich, for the Schweizer-Schleppschiffahrts-Genossenschaft. This boat, which is illustrated in Figs. 1 and 2, was constructed particularly for the service between Mannheim, Strasbourg and Basle, but it is also used on the Rhine between Rotterdam and Basle. The turbines normally develop 1,100 i.h.p. (950 shaft horse-power) and have a maximum output of 1,300 i.h.p., which is transmitted through a Krupp gear having a reduction ratio of 4,000 to 45 r.p.m. By the adoption of the geared-turbine construction, it was possible to build this tug having the dimensions of 213 ft. long between the perpendiculars, 26 ft. 3 in. over the frames, and a breadth over the paddle boxes of 56 ft., whilst the draught, when the tug was fully equipped with the requisite water and 10 tons of coal, was only 3 ft. 3 in. By comparison with data concerning other constructions, it will be seen that the Zürich is the most powerful paddle boat for its size which has yet been built.

In service, it has sometimes happened that the paddle wheels have struck submerged rocks or gravel banks so violently as to smash the paddles, but in spite of these severe tests, the gearing has withstood the impacts without damage of any description. The tug has been in continuous service since it was taken over by the owners, having already completed more than 11,000 working hours. Some alterations were made to the paddle wheel casings and boilers after the first runs, but it is satisfactory to report that the turbines and gearing have required practically no repairs during the whole of this period.

We have since developed the turbine-driven paddle idea still further, as will be seen from Figs. 3 and 4, which show the projected tug-boat of 1,400 h.p. for the Rhine, and Figs. 5 to 8, illustrating a projected saloon paddle boat for a Swiss lake. In these latter cases, Zoelly turbines, mounted directly on the gear casing, are employed, running at 10,000 r.p.m., and it will be realised that this design is decidedly superior to the former arrangement, in that the weight of machinery is less per i.h.p., the space required is smaller, and the steam consumption is considerably improved by the adoption of the high speed.

We shall be obliged if you will kindly give due publicity to the foregoing and thank you in anticipation.

Yours faithfully,

SOCIÉTÉ ANONYME DES ATELIERS DE CONSTRUCTIONS MÉCANIQUES,
ESCHER WYSS & CIE,
R. ZOELLY.

Zürich, May 20, 1925.

THE PROPOSED MERSEY ROAD TUNNEL.

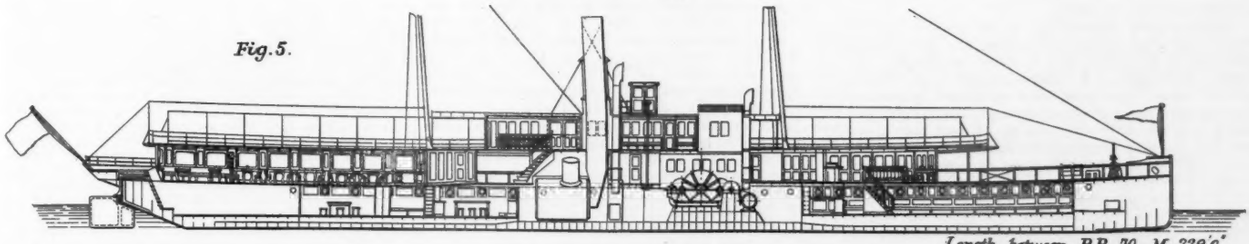
TO THE EDITOR OF ENGINEERING.

SIR,—It is hoped that a period of ten years' somewhat strenuous experience as a works engineer at Liverpool (and very many years elsewhere) may give the writer some warrant for again advancing his plea for a high-

GEARED-TURBINE PADDLE BOATS.

(*For Description, see opposite Page.*)

Fig. 5.



Length between P.P	*70 M.*	*229.0"*
Breadth over Frames.	*8·20 ,,*	*27·0"*
Depth Moulded.	*2·80 ,,*	*9·2"*
Draught.	*1·40 ,,*	*4·6"*

Fig. 6.

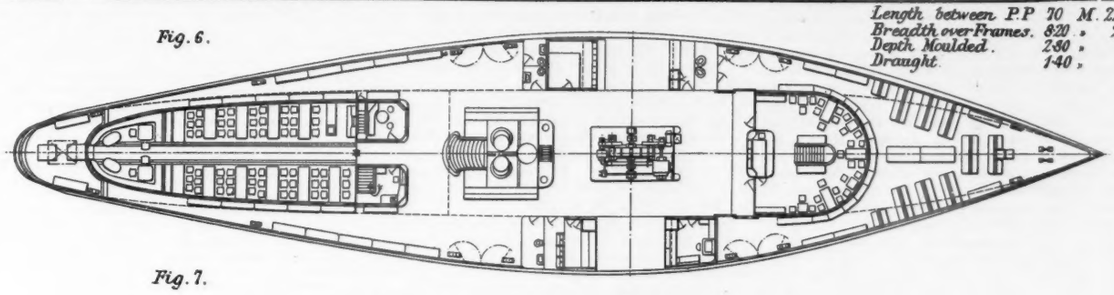


Fig. 7.

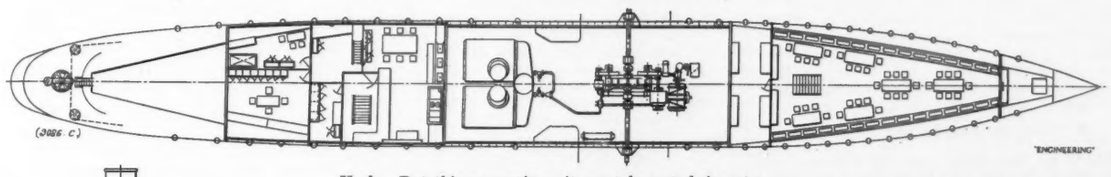
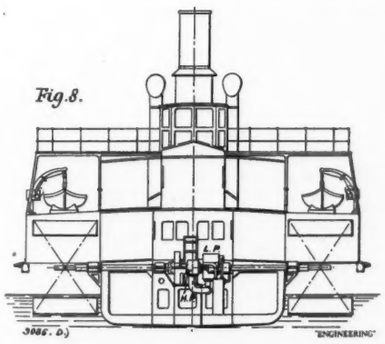


Fig. 8.



level bridge between Liverpool and Birkenhead, in lieu of, or in addition to, the present scheme for a tunnel which is now forming the subject of discussion before a Parliamentary Committee. Whilst wishing to avoid any controversial comment upon the proposal for this tunnel of 44 ft. internal diameter, one cannot help recalling the serious, and, at times, almost overwhelming disasters which befell the construction of much smaller tunnels—and from which the adjacent Mersey Railway tunnel was, during its progress, by no means exempt—resulting in huge permanent costs for pumping, and a woeful preclusion of dividends in consequence.

But the main argument, from an impartial point of view, would seem to be that no means of classification and control could possibly be exercised, in the case of a tunnel, as regards the mass of traffic produced from a great and busy city. It would be imperatively necessary to deal with at least three classes: (1) Heavy vehicles, such as motor-buses, chars-à-bancs, warehouse vans of 2 tons, private carriages or coaches, and two-horse tradesmen's vans; (2) light vehicles, motor-cars, motor-cycles, taxis, &c.; (3) pedestrian traffic. (The heavy lorry of the dock traffic, and the railway wagon and tramway cars are obviously excluded.)

It has long since become a chronic grievance that the Liverpool landing stage is, day after day, congested with this cross-river traffic, and the ferries, although admirably equipped and worked, cannot cope with it without insufferable delay; it is no unusual experience for vehicles to wait an hour and upwards for their turn. It may be confidently asserted that there are no difficulties in the way of constructing a bridge across the Mersey, other than those which have been successfully overcome—and on a far larger scale—in New York. But this comparison, it must be noted, is not quite a parallel one in the matter of land approaches, as it has long been admitted (or supposed) that the insuperable objections they present have put the Mersey bridge out of court.

But the writer now ventures to advocate the adoption of a bold and profuse application of the modern electrically-worked lift at the respective ends of the proposed bridge (which would preferably consist of three spans of 1,200 ft. each, of the suspended, built-out cantilever type), and the eight or nine lifts at each end would be arranged so as to meet the demands of a rapid and at the same time a classified and controlled traffic, both vehicular and pedestrian.

Trusting that the project may merit consideration,

I am, Sir, Yours, &c.,

HENRY A. DIBBIN.

Southfields, S.W. June 18, 1925.

SURVEY OF THE NATIONAL COAL RESOURCES.—One of the chief functions of the Fuel Research Board of the Department of Scientific and Industrial Research is a survey and classification of coal seams, situated in various mining districts, by means of physical and chemical tests in the laboratory. Where desirable, the latter are supplemented by large scale tests at H.M. Fuel Research Station, East Greenwich, or elsewhere. The Board has decided that the best way of carrying out this work is by means of local committees, and in pursuance of this policy a committee has recently been appointed to deal with the survey in the North Staffordshire area. The Colliery Owners' Association of that district, and the North Staffordshire Institute of Mining Engineers are co-operating in the work. Committees have, for some time, been actively engaged in the Lancashire and Cheshire and in the South Yorkshire areas.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—At the annual Summer Meeting of the Institution of Heating and Ventilating Engineers, held at Birmingham on June 23, Mr. H. G. Cathcart read a paper on "Hot-Water Supply Installations for Large Infectious Diseases and Mental Hospitals." Speaking of the extent of some of these hospitals, he stated that from 2,800 to 3,000 tons of coal are consumed per annum, in many of them, for steam raising alone, besides 500 to 850 tons for other purposes. The designing of plants, therefore, needed careful consideration. The author then spoke of the necessity for water softening in districts like London, the desirability of ample capacity in the storage of hot water, and the importance of providing spare or stand-by plant for use when a breakdown causes the stoppage of a portion of the essential services. Recording apparatus was of great value, and reliable meters and temperature registers provided most valuable and interesting data regarding the performance of a plant. It was desirable to utilise the best non-conducting covering composition for pipe lines, and equipment of a similar nature. The Metropolitan Asylums Board used only pure magnesia and plastic asbestos for this purpose.

ROYAL METEOROLOGICAL SOCIETY.

AT the closing meeting of this society for the present session, held on Wednesday, the 17th instant, the following papers were read:—

"*Report on the Phenological Observations in the British Isles from December, 1923, to November, 1924,*" by J. E. Clark, I. D. Margary and R. Marshall. In this report, 365 sets of records were discussed and compared with about 120 before 1922. Yet the north-western half of Ireland, and most of West and North Scotland, are still practically bare, and observers there are badly needed. Attention was called to two important developments—one in time, the other in space. Records have been discovered continued almost without break, by the Marshams of Stretton Strawless, since 1736, and therefore of great value. The need for universal, more or less co-operative, systematic observation was stressed in a letter to *Nature* last October, and important responses have resulted from widespread parts of the world. The year was described officially as "dull and very wet with a very cloudy summer." Again it began mild, the four weeks to February 10 averaging 6 deg. warmer than the succeeding four. Sudden heat-bursts again raised false hopes; the hottest period occurred at Easter. These made the records of plants, insects and birds again erratic. Mid-July alone gave a real taste of summer. Daytime was especially cool. Almost everything was much later than in 1923, and on the thirty years' average, flowers in the east and south-east were one to two weeks late; North England and Scotland still more. Yet the hazel was early; blackthorn, eleven days behind in South Britain, latest of all. Insects, appearing later, ranged from eighteen days late for the honey-bee, to three days only for the orange tip, with the meadow brown in June a week early. So too the migrants. On the ten-year average, the four earliest were four days late, the eleven latest only a day and a half late. Lateness and wet did not, however, spell poor blooming. That and vegetable growth were exceptional, and were little troubled by insect plagues, though slugs and snails were often seriously destructive and fungoid troubles bad. Tree fruit was scarce and of poor quality. Grain and hay were often hard to save; potatoes often diseased, but green crops and roots, in part, made amendments. The tables and charts exhibiting these results are the completest hitherto obtained.

"*Measurements of the Amount of Ozone in the Upper Atmosphere,*" by D. N. Harrison, B.A., and G. M. B. Dobson, D.Sc. Following the general method of Fahy and Buisson, but with somewhat simplified apparatus, the amount of ozone present in the atmosphere has been measured by spectroscopic means. Some 80 daily values have been obtained. A marked connection is

found between the general pressure distribution at the surface and the amount of ozone. The few cases where comparison is possible indicate a still closer connection between the conditions at about 10 km. and the amount of ozone.

"*Meteorological Periodicities of the Order of a Few Years, and their Local Investigation; with Special Reference to the Term of 5·1 Years in Britain*," by Joseph Baxendell. A limited number of definite periodic terms have now been confirmed by various investigators; each term appearing in several meteorological and allied records, and at different places, and generally in very similar form in both halves of the longer records, on each half being analysed separately. Sought for by the author, by harmonic analysis, in excellent data not previously used for such purposes, they have been found, almost exactly of the lengths alleged, and of appropriate phase-angles. Finally, the cumulative evidence of the reality of the following meteorological periodicities seems to be irresistible: 5·1, 3·1, 2·8, 2·4, 2·2 and 1·63 years. A list of foreign and feebler English cycles is added. Taking both lists together, several of the shorter terms are seen to be exact half-harmonics of certain of the longer ones, while one or two are third-harmonic components. Professor H. H. Turner's theory of "discontinuities" is sympathetically referred to, although the present author ascribes most deviations from the normal sine curves to "interfering" periodicities. The frequently markedly local incidence of the best cycles (asserted years ago by Dr. Mill) is emphasised, and a reasonably easy and accurate method of local analysis explained. The 5·1-year term was found at Southport in the 'eighties, and has since been independently detected by five investigators elsewhere, two of whom have traced it back for three centuries. It is especially pronounced in the frequency of the colder wind-directions, in Lancashire and at Greenwich; but values for the term in rainfall, temperature, air pressure, severe winters, and other data are also given.

MOTOR SHIPS FOR THE BANK LINE.—After completing satisfactory trials, the twin-screw motor ship Forresbank, built by Messrs. Harland and Wolff, Limited, Govan, was recently delivered to her owners, Messrs. Andrew Weir and Co. (Bank Line, Limited). A cargo vessel of the shelter-deck type and classed 100 A.1 at Lloyd's, she has a gross tonnage of 5,200 and is similar to the other vessels recently constructed for the Bank Line, one of which, the Clydebank, was described in our issue of February 13 last, on page 203. The Forresbank is propelled by two sets of six-cylinder Harland-Burmeister and Wain motors, and the auxiliaries are electrically operated. A sister vessel, the Weirbank, was launched at Govan on June 18. This latter is the fourteenth motor ship built at Messrs. Harland and Wolff's Works, for Messrs. Andrew Weir and Company. It is intended to launch another of these vessels early in July.

EXPLORATION OF AFRICA BY MOTOR CAR.—The Citroën Central African expedition, comprising eight caterpillar cars, under the leadership of Messrs. G. N. Haardt and L. Andouin Dubreuil, is now approaching its final goal. Setting out from Algeria on October 28, 1924, and crossing the Sahara and the Chad territory, the expedition proceeded to Stanleyville in the Belgian Congo. Moving eastward, Lake Albert was reached and crossed; upon disembarking at Butiabwa, the party proceeded towards Victoria Nyanza, arriving on the north shore on April 19. The expedition was here split into four groups, each consisting of two cars. One of these groups has reached Mombassa, another arrived at Dar-es-Salâm on May 14, a third group travelled south, along the west coast of Lake Nyasa, and is making for the coast of Mozambique. The fourth section is travelling south through Rhodesia, the ultimate object being Cape Town. The four groups will cross the Indian Ocean and intend to meet at Tamatave in Madagascar, from which point the expedition will return to France.

CONTRACTS.—The Ailsa Shipbuilding Company, Limited, of Troon and Ayr, have received an order to build a fast cargo and passenger steamer for the Isles of Scilly Steamship Company, Limited. She is intended for service between the Scilly Islands and the mainland. The vessel will be laid down in the builders' Troon yard, and the propelling machinery will also be supplied by the Ailsa Company.—The Westinghouse Brake and Saxby Signal Company, Limited, has received an order for electro-pneumatic decking plant for No. 3 Pit top at the Llanbradach Colliery of the Cardiff Collieries, Limited. The Metropolitan Railway Company has entrusted the same firm with the supply and installation of the whole of the apparatus required for re-signalling the widened line running between King's Cross and Moorgate. Of the alternating-current type, the installation involves the provision of about 80 automatic and semi-automatic signals with their train stops, and 76 track circuits, together with the requisite alterations to the interlocking at the King's Cross, Aldersgate, and Moorgate signal cabins. Each of the latter will be equipped with an illuminated diagram of the area it controls. The work has been commenced and is expected to be completed in about five months' time.

4-TON ELECTRIC LEVEL-LUFFING WHARF CRANE.

THE 4-ton electric travelling wharf crane, which we illustrate on page 802, forms one of a group of five constructed by Messrs. Alexander Chaplin and Co. Ltd., of Cranstonhill Engine Works, Govan, Glasgow, for the High Commissioner for the Union of South Africa. These cranes are to be erected at Durban Harbour, and are of the level-luffing type mounted on a high pedestal. Each crane is fitted with four motors, one for each motion, and is capable of handling working loads of 4 tons, between radii of 52 ft. 6 in. and 20 ft., on rails set to 11 ft. 9½ in. centres. The jib is balanced, as seen in the illustration, and the load is kept approximately level by means of a compensating pulley, over which the hoisting rope passes. A horizontal luffing speed of 120 ft. per minute is obtained.

The hoisting motor is of 50 brake horse-power, and is capable of lifting the full load of 4 tons at 125 ft. per minute. By means of a change-speed gear, a load of 2 tons may be raised at 250 ft. per minute. The slewing, luffing, and travelling motors are each of 10 brake horse-power. Actually the operation of luffing, at the speed mentioned above, only requires 5 brake horse-power, but in order to reduce the number of spares, this motor is made a duplicate of the slewing and travelling motors. Slewing is carried out at 400 ft. per minute, luffing at 120 ft. per minute, and travelling at 50 ft. per minute.

In connection with the electrical equipment, the hoisting motion is controlled by a contactor panel with a master controller, potentiometer braking being obtained on the lowering side. The controllers for the other three motors are of the plain series drum type. The hoisting, luffing and travelling motions are fitted with solenoid brakes and shunt self-resetting limit switches, and all controllers are interlocked with the crane panel. The gear wheels throughout the crane are of cast steel with machine-cut teeth, with the exception of the slewing pinion and rack. The superstructure revolves on a ring of live rollers. Before despatch, the crane was tested with a 50 per cent. overload, without the use of rail clips and blocking screws, and functioned under working conditions to the satisfaction of the Inspecting Engineer to the High Commissioner for the Union of South Africa.

BOOKS RECEIVED.

Engineering Geology. By H. REES, Ph.D., and THOMAS L. WATSON, Ph.D. Third edition, revised. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Tolley's Handbook of Income Tax, Super Tax, &c. Rates Allowances and Exemptions for 1925-26. By CHAS. H. TOLLEY. London: Waterlow and Sons, Limited. [Price 7*d.* net.]

Knickfestigkeit der Stabverbindungen. By Dr. Ing. H. ZIMMERMANN. Berlin: Wilhelm Ernst and Sohn. [Price 8·40 marks.]

Relativity: A Very Elementary Exposition. By Sir OLIVER LODGE, F.R.S. London: Methuen and Co., Limited. [Price 1*s.* net.]

Mechanical Appliances, Mechanical Movements and Novelties of Construction. By GARDNER D. HISCOX. Second Series. Fifth revised and enlarged edition. London: Constable and Co., Limited. [Price 21*s.* net.]

The Technology of Wood Distillation. By M. KLAR. Translated by Alexander Rule, D.Sc., Ph.D. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Der Talsperrenbau. (A.) Gesichtspunkte für die Anlage Grosser Wasserkräfte und Wassersammel-Anlagen. (B.) Talsperren aus Erde und Losem Steinmaterial. By P. ZIEGLER. Third edition, revised. Berlin: Wilhelm Ernst and Sohn. [Price 24 marks.]

Steam Power Plant Engineering. By G. F. GEBHARDT. Sixth edition, rewritten. New York: John Wiley and Sons, Inc. London Chapman and Hall, Limited. [Price 30*s.* net.]

Electric Vehicles. By CHARLES W. MARSHALL, B.Sc. London: Chapman and Hall, Limited. [Price 9*s.* 6*d.* net.]

Sewerage and Sewage Treatment. By HAROLD E. BABBITT, M.Sc. Second edition, revised. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 25*s.* net.]

Steam Boilers: Their Defects, Management and Construction. By R. D. MUNRO, M.I.M.E., and GEO. NESS, M.I.Mech.E. Sixth edition, revised and enlarged. London: Charles Griffin and Co., Limited. [Price 10*s.* 6*d.* net.]

The National Physical Laboratory: Report for the Year 1924. London: His Majesty's Stationery Office. [Price 8*s.* 6*d.* net.]

Power Station Operation. Vol. I. London: The Electrical Times, Ltd. [Price 3*s.* 6*d.*]

Chamber of Shipping of the United Kingdom: Annual Report, 1924–25. London: Witherby and Co.

Health and Environment. By LEONARD HILL, F.R.S., and ARGYLL CAMPBELL, M.D., D.Sc. London: Edward Arnold and Co. [Price 12*s.* 6*d.* net.]

A Catalogue of British Scientific and Technical Books, 1925. New edition, revised and enlarged. London: British Science Guild, and A. and F. Denny, Limited. [Price 12*s.* 6*d.* net.]

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The contrast in conditions in different sections of the iron and steel trades tends to become more pronounced. In some quarters, exception is taken to what is alleged to be the unduly pessimistic tone prevailing elsewhere. The actual facts appear to be that, while in the lighter branches turnover is maintained at a substantial level, the position in those departments supplying raw and semi-finished materials is unimproved, and orders are badly needed. The slump in coal exports from South Yorkshire is not only affecting sales of colliery stores, wagons, coal-cutting machinery and the like, but is retarding forward contracts in the iron and steel branches. The possibility of the advent of cheaper fuel seems to be influencing users of raw and semi-manufactured iron and steel to hold off the market, in the hope that this will be reflected in still cheaper iron and steel. Following the reduction reported in soft steel billets, a reduction of 10*s.* per ton is notified in the minimum quotation for Seimens acid billets, bringing that quotation to 11*l.* per ton. Order books in pig-iron and common steel are very unsatisfactory, and if there is any improvement in the actual condition of buying it will not be reflected in production for the next few weeks, owing to activity being restricted for half-yearly stock-taking. In the engineering trades, the most satisfactory feature is that relating to requirements of electrical machinery and fittings. On home account, the automobile trades continue good customers for constructural parts and fittings, particularly for magnets. Railway material manufacturers have benefited substantially from orders for renewals and replacements from British companies, but are somewhat anxious on account of the big proportion of orders for railway springs, &c., which are being placed with Continental rivals. A further improvement is shown in the home and export trade in agricultural tools and edge tools. British farmers have been larger buyers of cutting parts for agricultural machines than they were a year ago.

South-Yorkshire Coal Trade.—No further reductions in prices are recorded, though the market presents many weak features. Inland deliveries of best steams are maintained at a substantial level, but the amount of business booked on export account falls far short of production capacity, and keen competition results in frequent fluctuation of prices. Orders for cobbles and nuts are readily met from stock. Washed slacks are firmer owing to reduced output. Business in house coal is at the seasonal minimum. Quotations: Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 27*s.*; Derbyshire best brights, 23*s.* to 26*s.*; Derbyshire best house, 21*s.* to 23*s.*; Derbyshire best large nuts, 17*s.* 6*d.* to 20*s.*; Derbyshire best small nuts 12*s.* to 14*s.*; Yorkshire hards, 17*s.* 6*d.* to 21*s.*; Derbyshire hards, 17*s.* 6*d.* to 21*s*; Rough slacks, 10*s.* to 12*s.* 6*d.*; Nutty slacks, 8*s.* 6*d.* to 10*s.*; Smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

THE LINING OF BEARINGS.—A small pamphlet, giving practical hints on the lining of bearings, has recently been issued by the Hoyt Metal Company of Great Britain, Limited, Deodar-road, Putney, London, S.W. 15. Detailed instructions are given, in the booklet, as to the preliminary tinning of the bearing shell, the heating of the white metal and the importance of casting temperature, the pouring of the melt, and the finishing operations. Suitable outfits for lining bearings on a small scale are suggested and directions for making jigs or moulds for small half-bearings are included. Copies of the pamphlet may be obtained on application to the firm at the above address.

MESSRS. RD. JOHNSON, CLAPHAM AND MORRIS LIMITED.—The Ronald Lindsay Johnson playing fields, for the use of the employees of Messrs. Rd. Johnson, Clapham and Morris Limited, Manchester, were declared open on June 20, last. The grounds are situated in St. Mary's-road, Newton Heath, in the highest part of Manchester, and are some 8 acres in area. The late Captain R. L. Johnson, who, at the time of his death in 1917, while on active service in France, was Chairman of the Directors of the Company, directed, in his will, that certain funds should be set aside for the benefit of the employees of the firm, and the new recreation ground is the outcome of a scheme prepared by the executors. Additional donations have been made by the Board of Directors of the Company, and by the Trustees, to cover all rates and taxes on the land, and to provide a surplus towards costs of maintenance and upkeep.

WIRELESS OF THE MISSION SHIP "STRATHCONA II."—Built to replace the Strathcona, lost off Newfoundland two years ago, the ss. Strathcona II, owned by the Royal National Mission to Deep Sea Fishermen, has been equipped with Marconi apparatus and a special wireless receiver. The only ship belonging to the Mission to be fitted with a wireless transmitter, she will carry stores and patients to the hospital stations on the shores of Newfoundland and Labrador, and will render medical aid to fishermen on those coasts. The wireless transmitter is the standard Marconi ½-kw. quenched-spark installation for ships, and the specially-constructed single-valve receiving apparatus is suitable for all wave-lengths, and is thus capable of receiving meteorological bulletins, time signals and other information of special value to the fishing fleets. The Strathcona II is only 85 ft. long, and is one of the smallest ships to cross the Atlantic. Starting from Great Yarmouth, she put into Southampton, and, leaving that port on June 9, arrived at Vigo, Spain, on June 13. The route followed was via the Azores to St. Johns, Newfoundland.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The limited output of Cleveland pig-iron is more than ample for the very moderate demand, and even with the threatened further curtailment of production, supply promises to be sufficient for requirements. Sales for dispatch to destinations abroad are hardly heard of, but some expansion in local business is reported, customers here having exhausted their stocks and having been compelled to enter the market, with the result that a few contracts have been made for delivery over the third quarter of the year. No. 1 is 77*s.*; No. 3 g.m.b., 73*s.*; No. 4 foundry, 72*s.*; and No. 4 forge, 71*s.*

Hematite.—The situation in the East-Coast hematite department shows little change. Stocks are still heavy, and makers, in their anxiety to reduce them, are prepared to make slight price concessions. The general quotation for Nos. 1, 2 and 3 may be given at 78*s.* One or two home sales have been put through. Export inquiries are few and small.

Foreign Ore.—So far as is ascertainable, there is absolutely nothing passing in foreign ore. Sellers still base market rates on best rubio at 21*s.* 6*d.* c.i.f. Tees.

Blast Furnace Coke.—Durham blast furnace coke is in ample supply, and is slow of sale. Good medium qualities are in the neighbourhood of 21*s.*, delivered to local consumers.

Manufactured Iron and Steel.—Business in nearly all branches of manufactured iron and steel is very quiet, and quotations are unsteady. A few transactions in semi-finished materials, in constructional steel, and in railway requisites are reported. Sheet makers are well sold, but shipbuilding requirements are still meagre, and most other branches are very quiet. Common iron bars are 11*l.* 12*s.* 6*d.*; iron rivets, 13*l.* 10*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 7*l.* 10*s.*; steel billets (medium), 8*l.* 10*s.*; steel billets (hard), 9*l.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 8*l.* 10*s.*; steel angles, 8*l.* 5*s.*; steel rivets, 13*l.*; steel joists, 8*l.* 5*s.*; heavy steel rails, 8*l.* 10*s.*; and galvanised corrugated sheets, 16*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Business in the Scottish steel trade during the past week has been very slow, and no improvement of any kind falls to be reported. The shipbuilding industry, which formerly took up so much of the local output, is at such a low ebb that there is almost no demand for material from that quarter. Orders for new ships are so scarce that little is required, and even a part of that is coming in from the Continent. The general demand is poor, and any lots inquired for are still for present requirements, forward buying being practically nil In the black-sheet trade, a fair amount of business is passing, but much of the current demand is for small parcels for early delivery. Order books are well filled meantime. The same is the case with the makers of galvanised sheets, and active conditions rule all round, prices being well maintained. Other prices continue to be easier, and, in many instances, are a matter of arrangement. The following may be taken as the current quotations:—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 8*l.* 12*s.* 6*d.* per ton; sections, 8*l.* 2*s.* 6*d.* per ton; and sheets, $\frac{1}{16}$ to $\frac{1}{8}$ in., 10*l.* per ton, all delivered Glasgow.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade there has been no change over the week and the works are exceedingly quiet. Orders are very difficult to pick up and the outlook continues very clouded. In the re-rolled steel departments there is a limited amount doing, but competition is so keen that to book fresh lots extremely low prices have to be quoted. The current price for Crown bars is 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A dull tone still characterises the Scottish pig-iron trade and only part of the output is going into consumption. Producers are being faced with competition from the Continent in foundry grades at very low prices, and some fairish lots have recently been delivered in this area. To meet the prices being quoted is well-nigh impossible on the part of local makers. The demand for hematite iron is very poor. The following are to-day's quotations:—Hematite, 4*l.* 6*s.* per ton, delivered at the steel works; foundry iron No. 1, 4*l.* 6*s.* per ton; and No. 3, 4*l.* 4*s.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ended last Saturday, June 20, amounted to 1,082 tons. Of that total, 944 tons went overseas and 138 tons coastwise. For the corresponding week of last year the figures were 827 tons on foreign account and 95 tons coastwise, making a total shipment of 922 tons.

Shipbuilding.—A contract has been secured by the Ailsa Shipbuilding Company, Limited, of Troon and Ayr, to build a fast steamer for the Isles of Scilly Steamship Company, Limited. This vessel is for the owners' trade between the Scilly Isles and the mainland, carrying passengers, flowers and produce. She will be built at the Troon yard and the builders will also supply the machinery.—The Fairfield Shipbuilding and Engineering Company, Limited, Glasgow, have received an order for a twin-screw motor ship, of about 7,500 tons, for Messrs. Bibby Brothers and Co., Liverpool. The propelling machinery will consist of twin sets of Fairfield-Sulzer internal-combustion engines.—The Coaster Construction Company, Limited, Montrose, have obtained an order for a motor-propelled passenger and cargo vessel, 200 ft. in length, for the Western Australian Government State Shipping service.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Though the coalowners have officially announced their decision to terminate the present national wages agreement by giving a month's notice to the mine workers on June 30 next, the general demand for all classes of Welsh coal continues extremely quiet and insufficient to absorb even the restricted output which is being produced as the result of many permanent stoppages in the coalfield and frequent and numerous temporary stoppages. Indeed, colliery owners find it impossible to keep the pits working anything like regularly, so poor is the supply of tonnage because of the lack of orders, that it is impossible to secure a prompt return of empty wagons to keep the pits going. Prices, in the circumstances, are very irregular, being dependent on individual positions, with best Admiralty large from 25*s.* 6*d.* to 26*s.*, seconds 24*s.* 6*d.* to 25*s.* 6*d.*, Monmouthshires 22*s.* 6*d.* to 25*s.*, and drys from 23*s.* to 25*s.* 6*d.* Smalls are plentiful, the best bunker sorts being available at 14*s.* 6*d.*, with inferiors from 10*s.* 6*d.* up. For the second half of July, sellers, in view of the uncertain outlook, are not prepared to accept current figures, preferring to await developments, but buyers, too, are following a waiting policy and business is negligible. Last week 436,920 tons of coal were shipped as cargo foreign from South Wales, 264,910 tons going from Cardiff, 77,580 tons from Newport, 36,680 tons from Swansea, 55,300 tons from Port Talbot, and 2,450 tons from Llanelly. Of the total, 48,430 tons were dispatched to Argentina, 55,350 tons to Egypt, 99,650 tons to France, 64,650 tons to Italy, and 23,550 tons to Portugal. In May, 2,547,999 tons of coal, coke and patent fuel were shipped from South Wales, compared with 2,408,436 tons in April. Coal exports alone amounted to 2,445,044 tons, against 2,304,057 tons, of which foreign cargo comprised 2,030,678 tons, compared with 1,894,841 tons, foreign bunkers 298,405 tons against 300,406 tons, and coastwise cargo 115,961 tons against 108,810 tons. Patent fuel shipments amounted to 94,362 tons against 96,674 tons, and coke exports to 8,593 tons against 7,705 tons. The average price realised for coal exported foreign in May was 23*s.* 10½*d.* per ton, 1½*d.* less than in April, smalls averaging 18*s.* per ton, which was the same as in April; through 20*s.*, an increase of 1*s.* per ton, and large 26*s.* 9*d.*, a reduction of 2*d.* per ton. Anthracite coal, however, averaged 31*s.* 9*d.* per ton, or 7*d.* more than in April.

Iron and Steel.—Exports of iron and steel goods in the past week totalled 10,388 tons, compared with 14,005 tons in the previous week. Shipments of tinplates and terneplates amounted to 8,131 tons against 2,988 tons, blackplates and sheets 728 tons against 4,710 tons, galvanised sheets 3,990 tons against 1,083 tons, and other iron and steel goods 446 tons against 2,317 tons. With the trouble in the Far East, shipments of tinplates to Shanghai have been suspended, while the discontent of the tinmen is also causing anxiety to Welsh tinplate makers, and there is talk of closing some of the works.

TRIAL TRIP OF SS. "DUC DE BRABANT."—Built at the Wallsend yard of Messrs. Swan, Hunter and Wigham Richardson, Limited, for Messrs. L. Dens and Company, the Duc de Brabant, a steel single-screw steamer, ran successful trials off the mouth of the River Tyne, on June 19. The Duc de Brabant is a sister ship of the Koningin Elizabeth, recently described in ENGINEERING.

ALSATIAN POTASH PRODUCTION.—A report issued by the Société Générale Alsacienne de Banque, Strasbourg, quoted by the Department of Overseas Trade, 35, Old Queen-street, London, S.W.1, gives the following details as to the production of potash salts in the Haut-Rhine potash mines: in April, 1924, the total salts obtained amounted to 72,700 metric tons, the potash content being 20,450 metric tons. The corresponding figures for April, 1925, were 80,500 metric tons and 22,500 metric tons respectively.

CUTLERY STEELS.—In a paper read recently before the Sheffield Metallurgical Association, Mr. P. B. Parks discussed the manufacture and properties of the plain carbon and stainless steels used in the manufacture of cutlery. Shear steel, which was still produced by a process identical with that obtaining a hundred years ago, was holding its own in certain fields in spite of the advent of stainless steel. Genuine shear-steel blades possessed excellent cutting properties which rendered them highly suitable for various domestic purposes, and, in certain trades, the demand for this class of steel was insistent. The forging and heat-treatment of a stainless steel blade was to a large extent regulated by the chemical composition of the steel. The question of slag inclusions was one of great importance as the stain-resisting properties of a finished blade were very dependent on a perfect surface and polish. Crucible melted stainless steels were much more susceptible to surface defects than were those made in the electric furnace. Casting conditions in the latter process were altogether superior and, for this and other reasons, the lecturer was of opinion that, as far as stainless steels were concerned, electric-furnace melting was much more advantageous than crucible melting.

NOTICES OF MEETINGS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, June 27, at 2.30 p.m., in the Lecture Theatre of the Institute, Newcastle-upon-Tyne. "A Few Notes on the 'Safety First' Movement," by Mr. Paul S. Lea. "The Scientific Control of Coal-Washing by the Combined Application of Ash Characteristic Curves and X-Ray Examination," by Mr. William McLaren, M.A., B.Sc., Mr. C. Norman Kemp, B.Sc., and Mr. J. Leslie Thomson, B.Sc.

THE INSTITUTION OF WATER ENGINEERS.—Summer General Meeting. Tuesday, June 30, to Saturday July 4, at the Geological Society, Burlington House, Piccadilly, W. 1. Tuesday, June 30, at 10.30 a.m. Presidential Address by Mr. A. E. Cornewall-Walker, M.Inst.C.E. "The Effect of Contractions in Open Channels and the Measurement of Discharge in Open Channels by a Venturi Flume," by Professor A. H. Jameson, M.Sc., M.Inst.C.E. "Recent Studies Relating to the Purification of Water and the Action of Various Waters on Lead and Copper Pipes," by Dr. John C. Thresh, M.D., D.Sc., and Dr. John F. Beale, B.A., M.R.C.S. "Chesterfield New Waterworks," by Mr. Charles Boldry. "The Afforestation of Catchment Areas," by Colonel J. R. Davidson, C.M.G., M.Sc. At 7.30 p.m., Annual Dinner at the Hotel Russell, Russell-square, W.C. 1. Thursday, July 2, at 10 a.m. Visits to the Works of the Metropolitan Water Board, Staines Reservoirs, Littleton Reservoir, and Hampton Works. Friday, July 3, at 10 a.m. Various Visits. Saturday, July 4. Visits to other works of the Metropolitan Water Board.

THE SOCIETY OF MOTOR MANUFACTURERS AND TRADERS.—At a meeting of the Council of the Society of Motor Manufacturers and Traders, Limited, held on June 18, the following officers were elected for the current year: President, Sir William M. Letts, K.B.E.; Vice-Presidents, Messrs. R. W. Maudslay and W. Peto; Honorary Treasurer, Mr. Leslie Walton.

TENDERS.—The Department of Overseas Trade announces that a commission agent and manufacturers' representative at Rio de Janeiro is desirous of receiving catalogues and quotations from British manufacturers of wood-burning tractors. Further particulars may be obtained from the Department, 35, Old Queen-street, London, S.W. 1, quoting reference A.X. 2146.

SALVAGE OPERATIONS AT SCAPA FLOW.—On June 19, Messrs. Cox and Danks, Limited, were successful in raising their thirteenth German destroyer, the S. 32, at Scapa Flow. The vessel took nine days to lift, or twice as long as each of its twelve predecessors. This delay was due to a gale which persisted almost from the time the floating docks moved out. The firm are hoping, however, to lift their fourteenth ship before the end of June, making a total of three vessels raised in one month. This, if successful, will constitute a record.

THE TEMPORARY WATERLOO BRIDGE.—We regret that in referring to the photographer who supplied us with the illustrations from which we prepared the blocks in our article in last week's issue on the temporary Waterloo Bridge, a printer's error was made in his name. These photographs were the work of Mr. Ernest Milner, of 3, Moss Hall Villas, Ballard Lane, North Finchley, who has had great experience in this class of photography in the course of his 30 years' association with public works.

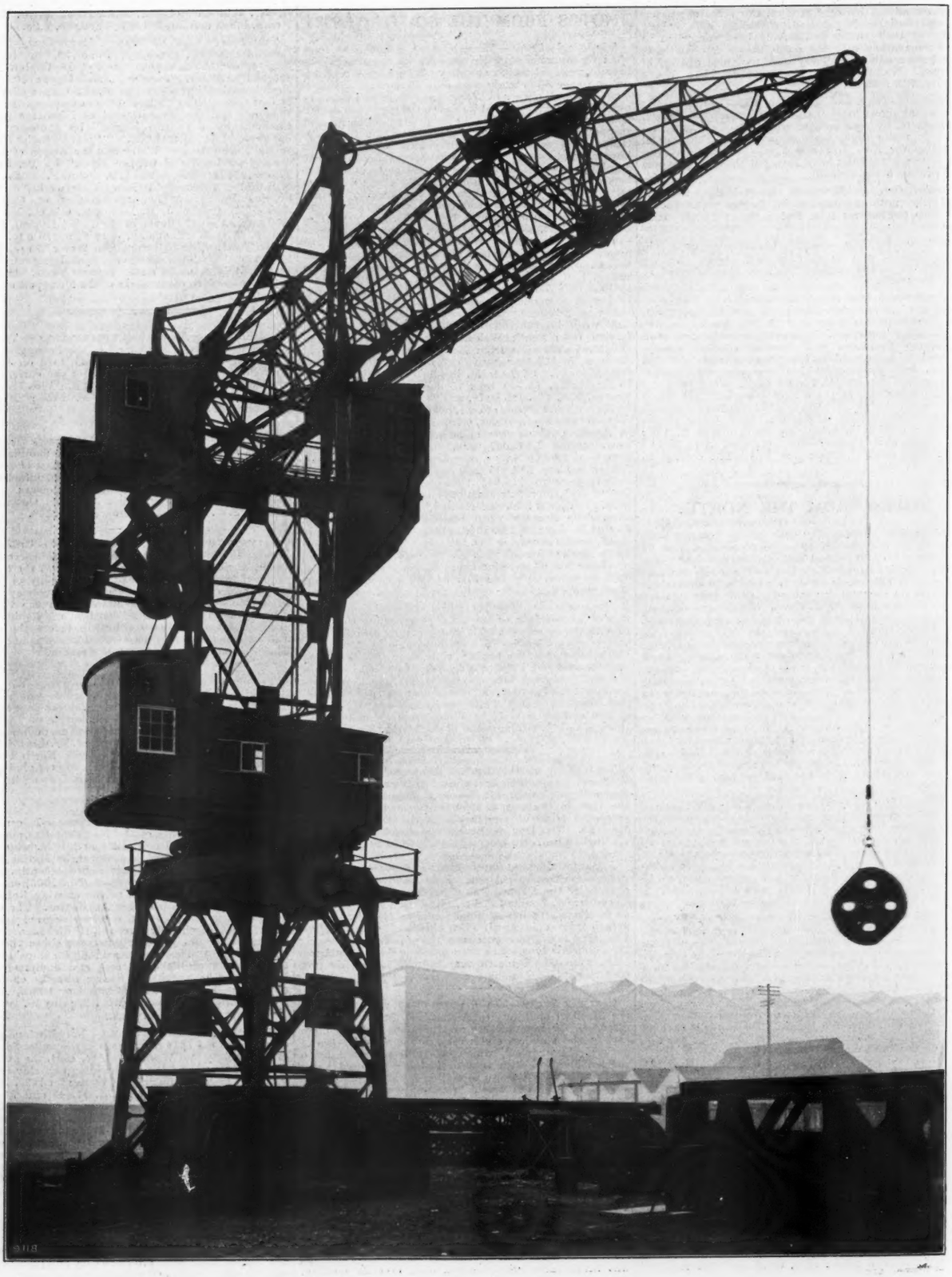
SURVEY OF LIFE-SAVING APPLIANCES.—In connection with the requirements of the Merchant Shipping (Life-Saving Appliances) Rules, 1924 and 1925, which come into force on July 1 next, the Mercantile Marine Department of the Board of Trade issued recently, for the guidance of surveyors, a circular (No. 1655) containing additions and amendments to the existing Regulations for the Survey of Life-saving Appliances. The circular deals with motor lifeboats, wireless-telegraphy installations and searchlights for ships' lifeboats, buoyant apparatus for foreign-going passenger ships, the illumination of ships' sides, condensed milk for ships' lifeboats, and stowage of lifeboat stores and equipment. The leaflet may be purchased, either directly or through any bookseller, from H.M. Stationery Office, Adastral House, Kingsway, London, W.C. 2, price 1*d.*

SHIPBUILDING REGULATIONS.—Notwithstanding the operation of the 1914 regulations, made under Section 79 of the Factory and Workshops Act, 1901, the number of accidents reported from shipbuilding and ship-repairing yards has remained high. The figures for 1920, 1921 and 1922 were, respectively, 15,452, 11,447 and 7,744 (the latter figure does not include Ireland). A departmental committee, on which both employers and workers were represented, was appointed in 1923, to inquire into the circumstances and causes of accidents, and, as a result of their unanimous recommendations, a new series of regulations has been drafted by the Home Secretary, in lieu of the existing regulations, dated April 4, 1914. Copies of these draft regulations may be obtained on application to the Factory Department, Home Office, London, S.W.1. The main items considered are: Means of access, gangways and ladders, the construction of staging, precautions against injurious fumes and explosions, precautions against injury from falling materials, and regulations relating to electricity and lighting, training and supervision, and ambulance provisions.

4-TON ELECTRIC LEVEL-LUFFING WHARF CRANE FOR DURBAN.

CONSTRUCTED BY MESSRS. ALEXANDER CHAPLIN AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 800.)



THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

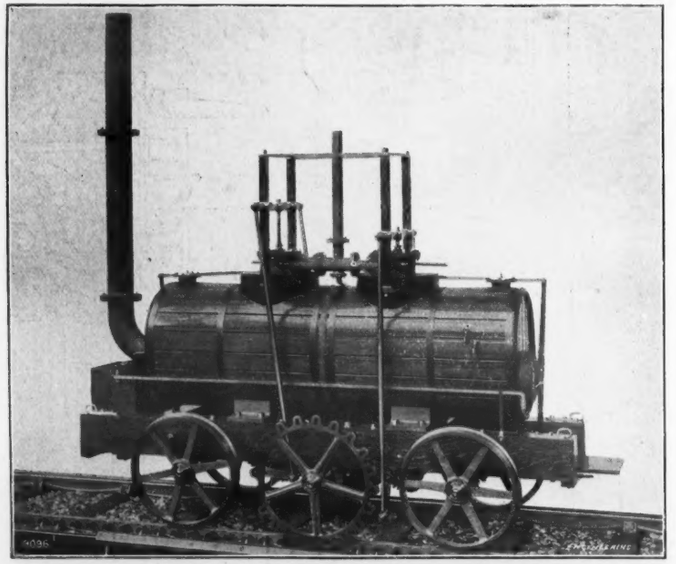


FIG. 7. BLENKINSOP'S LOCOMOTIVE, 1811.

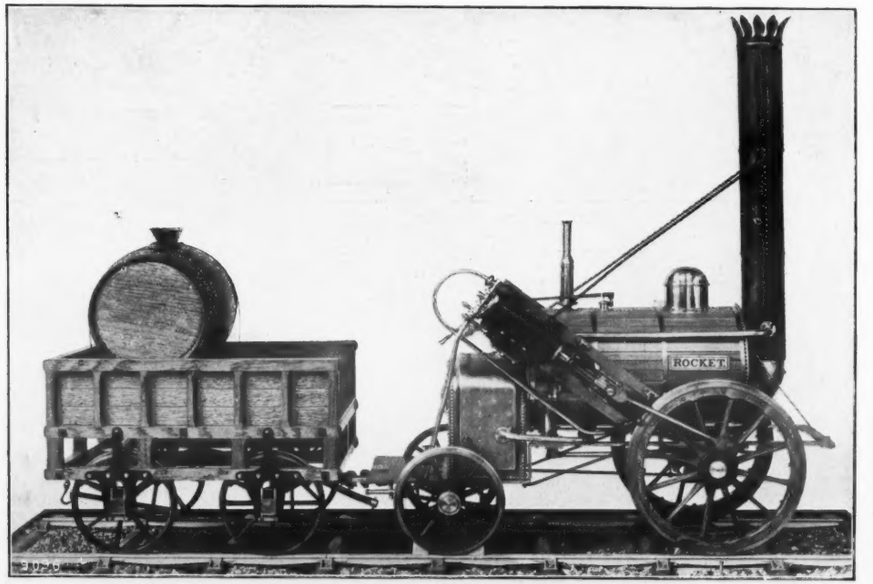


FIG. 8. STEPHENSON'S ROCKET, 1829.

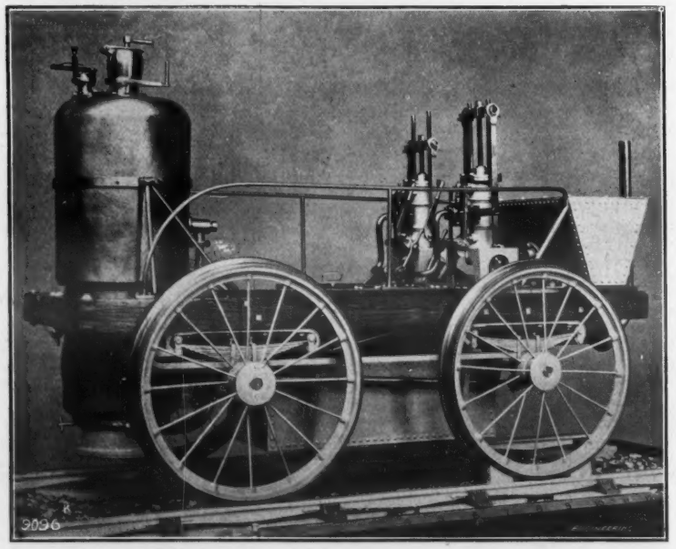


FIG. 9. BRAITHWAITE AND ERICSSON'S NOVELTY, 1829.

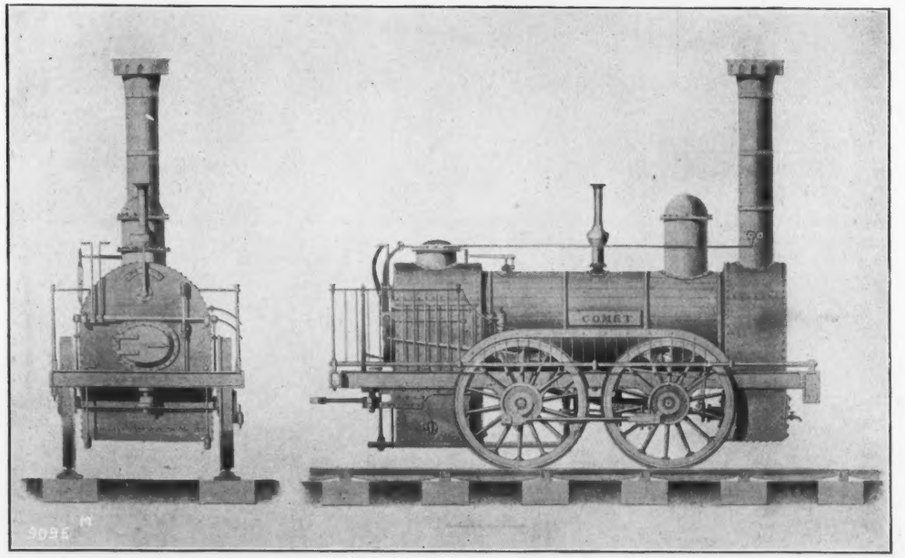


FIG. 10. HAWTHORN'S COMET. 1835.

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

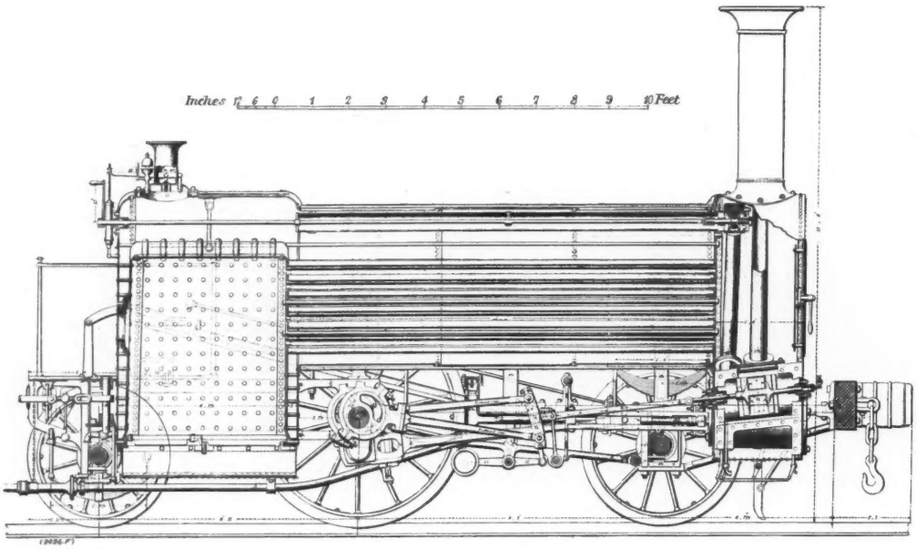


FIG. 11. BURY'S WREKIN; ABOUT 1846.

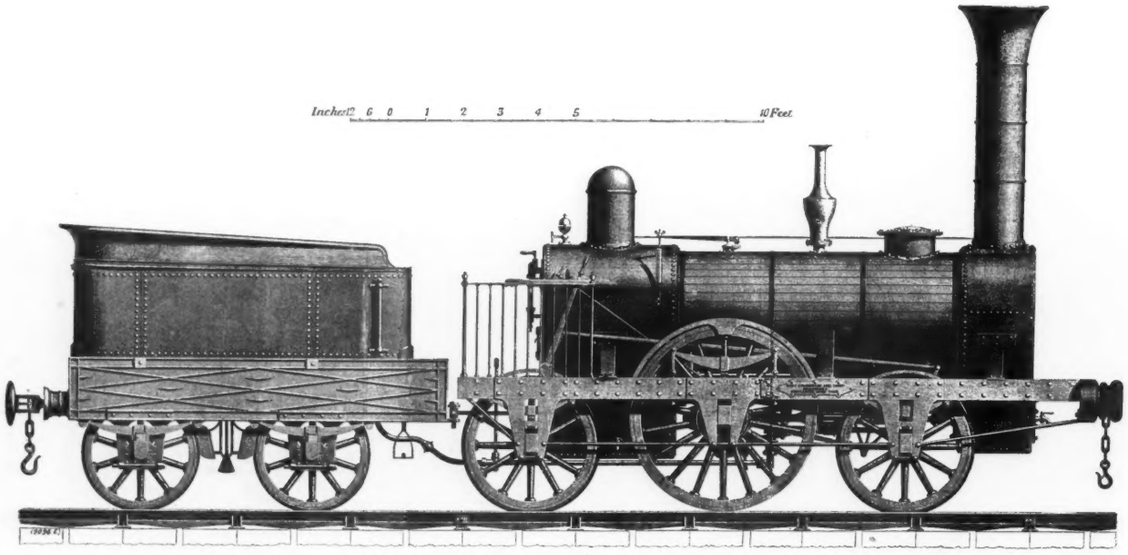


FIG. 12. STEPHENSON'S HARVEY COMBE, 1835.

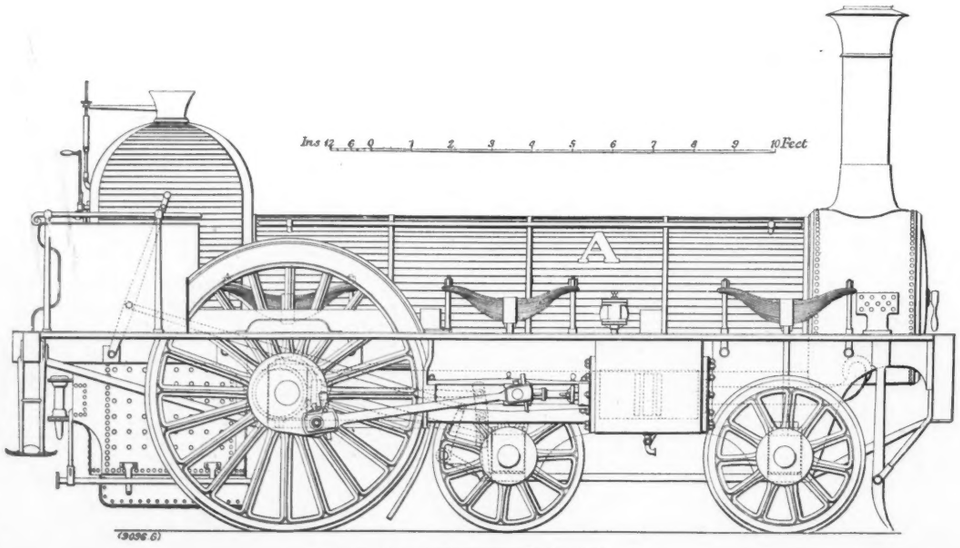


FIG. 13. STEPHENSON'S A, 1845.

(*To face page* 787.)

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

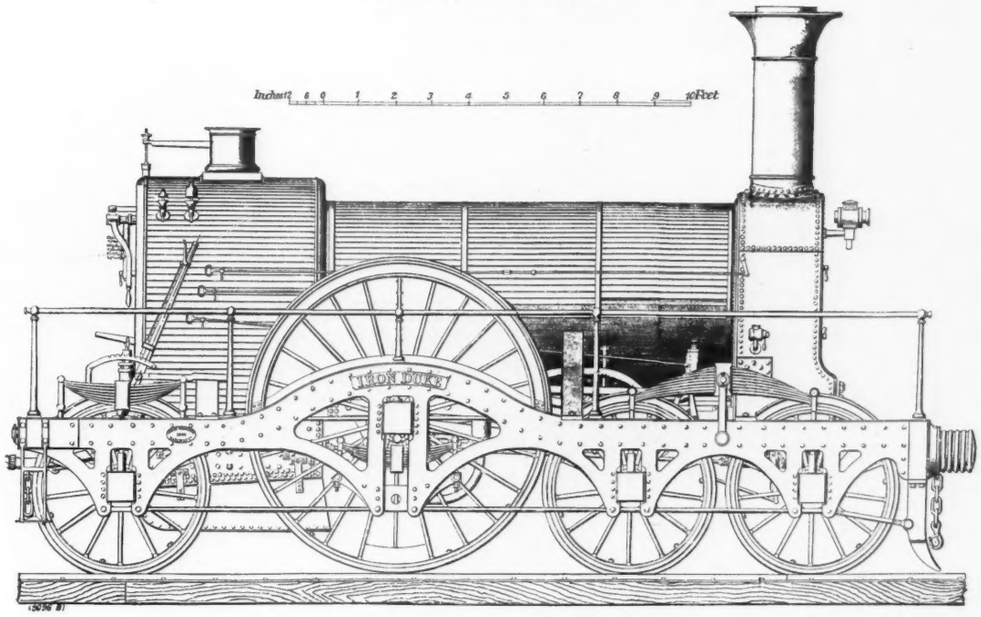


FIG. 19. GOOCH'S IRON DUKE, 1847.

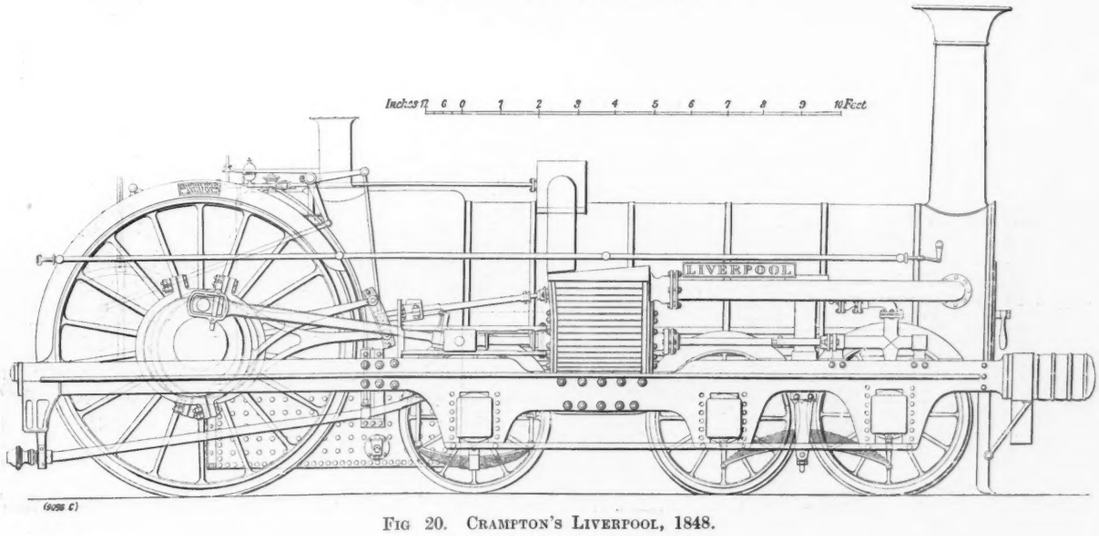


FIG 20. CRAMPTON'S LIVERPOOL, 1848.

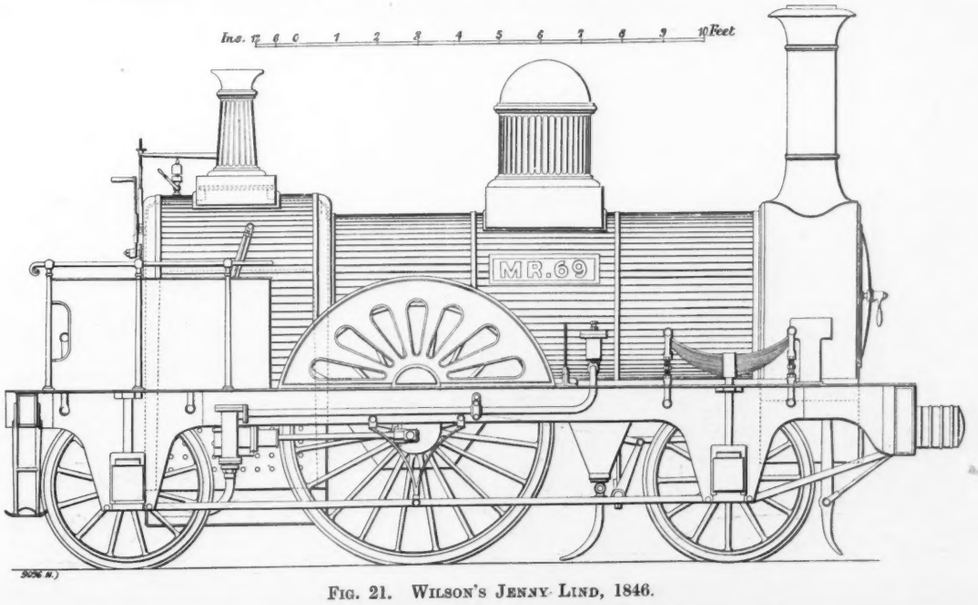


FIG. 21. WILSON'S JENNY LIND, 1846.

To face page 788.)

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

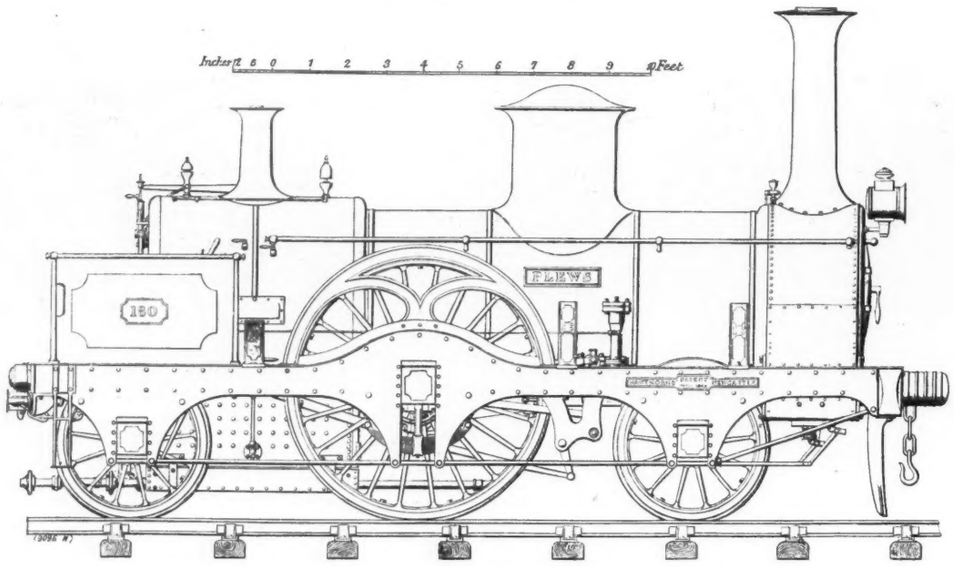


FIG. 22. HAWTHORN'S PLEWS, 1848.

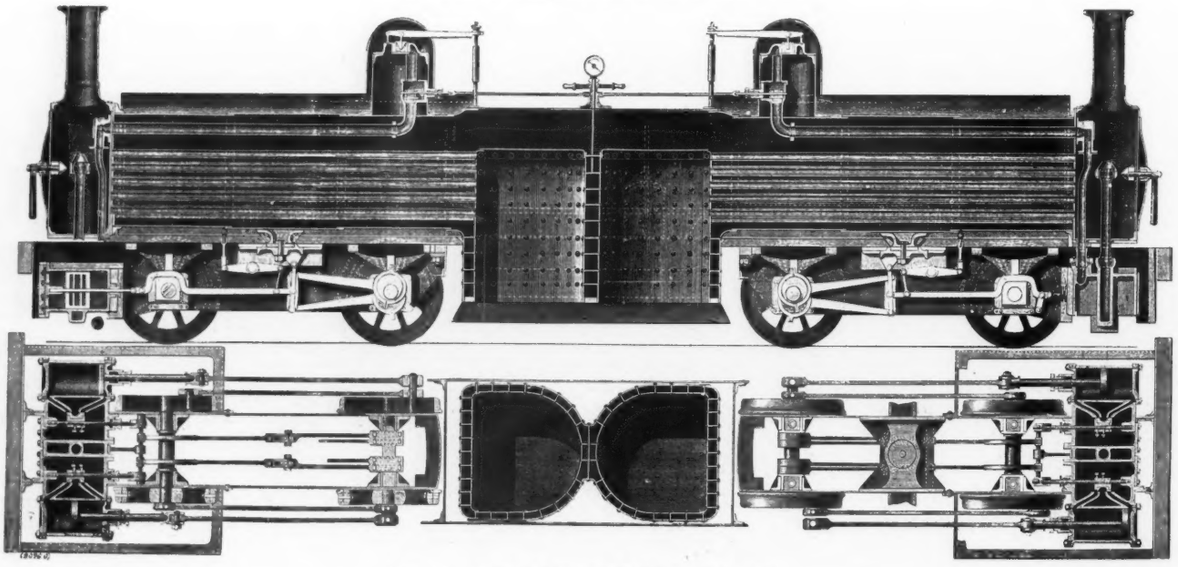


FIG. 23. FAIRLIE'S DOUBLE-BOGIE TYPE, 1864.

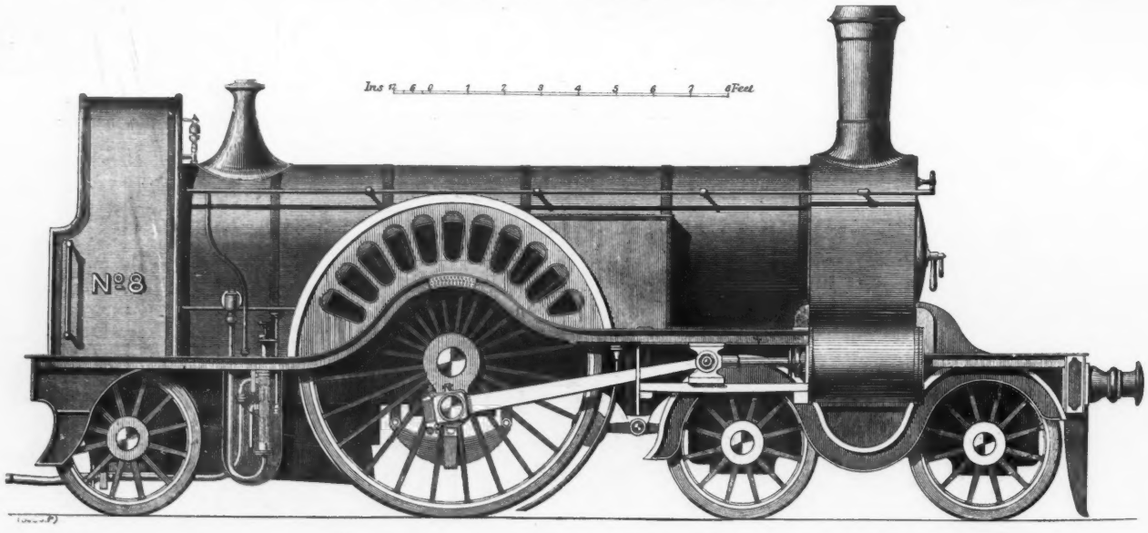


FIG. 24. STIRLING'S No. 1 CLASS, 1870.

(*To face page* 789.)

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

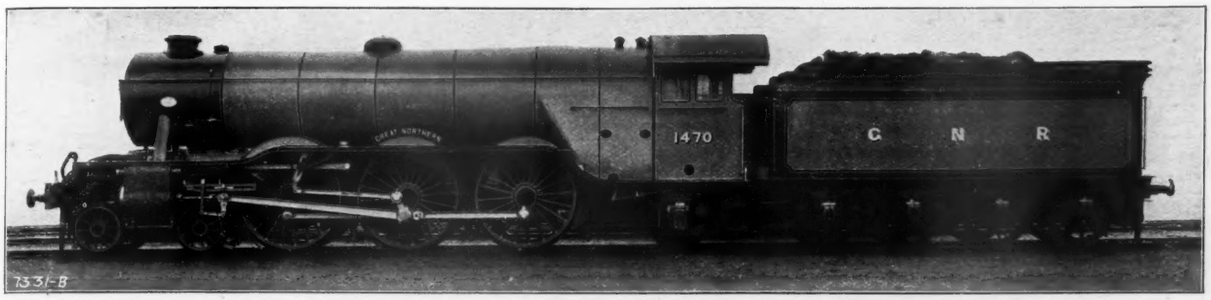
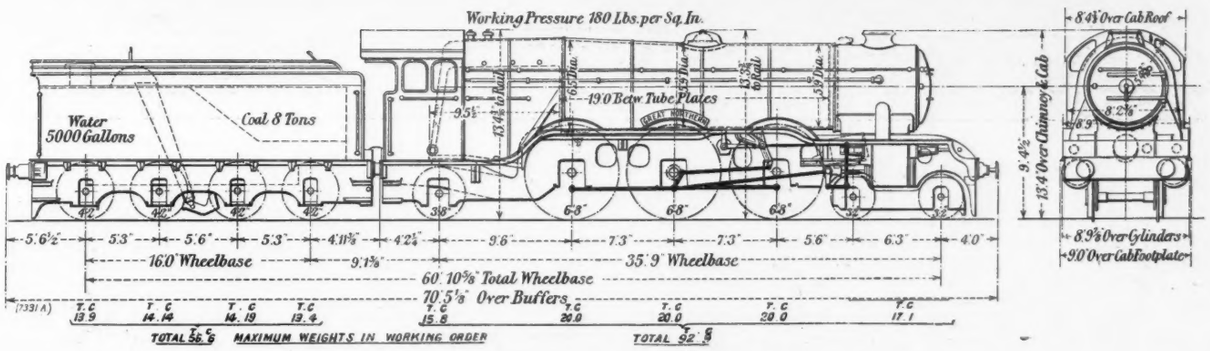


FIG. 29.



FIGS. 29 AND 30. 4-6-2 TYPE PASSENGER LOCOMOTIVE; GREAT NORTHERN RAILWAY.

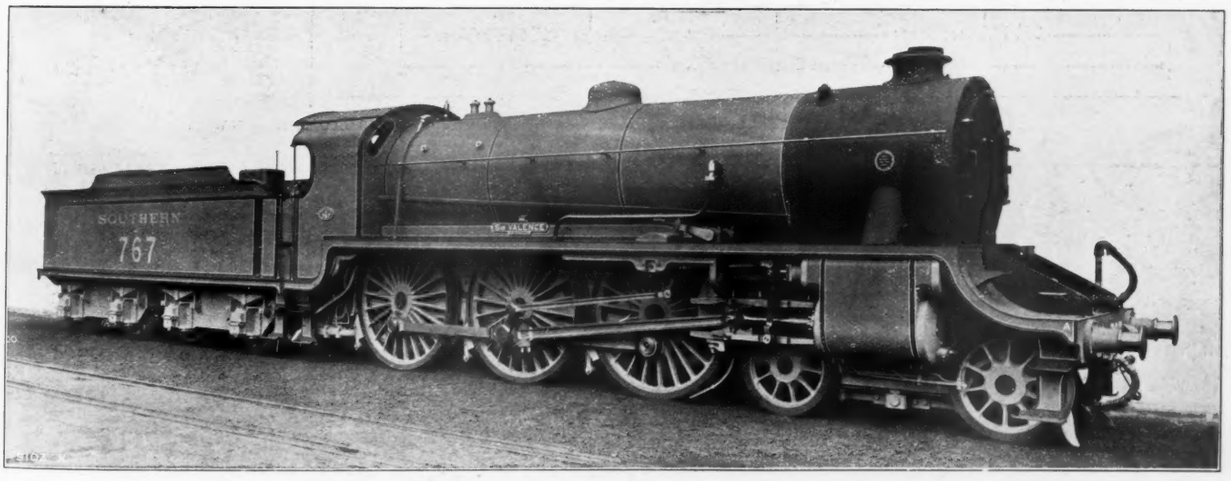
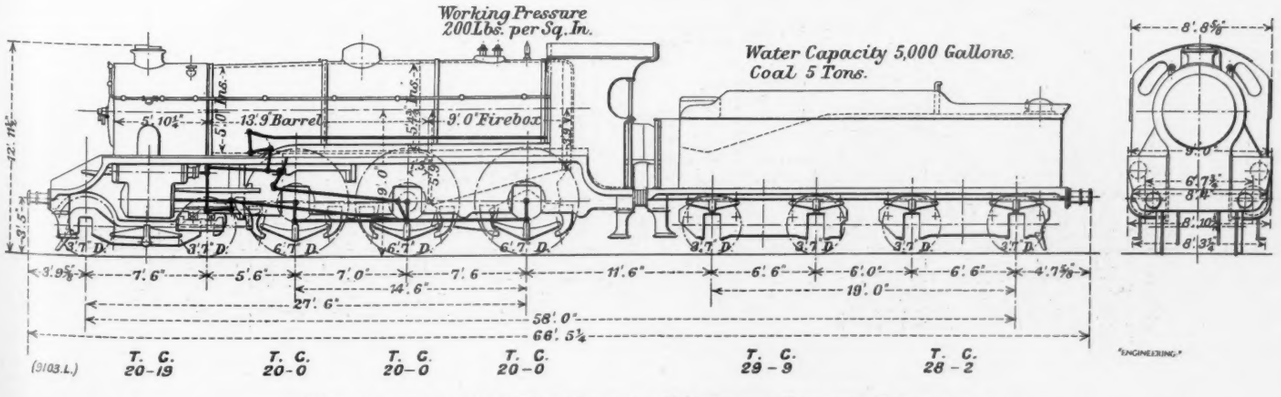


FIG. 31.



FIGS. 31 AND 32. 4-6-0 TYPE PASSENGER LOCOMOTIVE; SOUTHERN RAILWAY.

(*To face page* 790.)

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

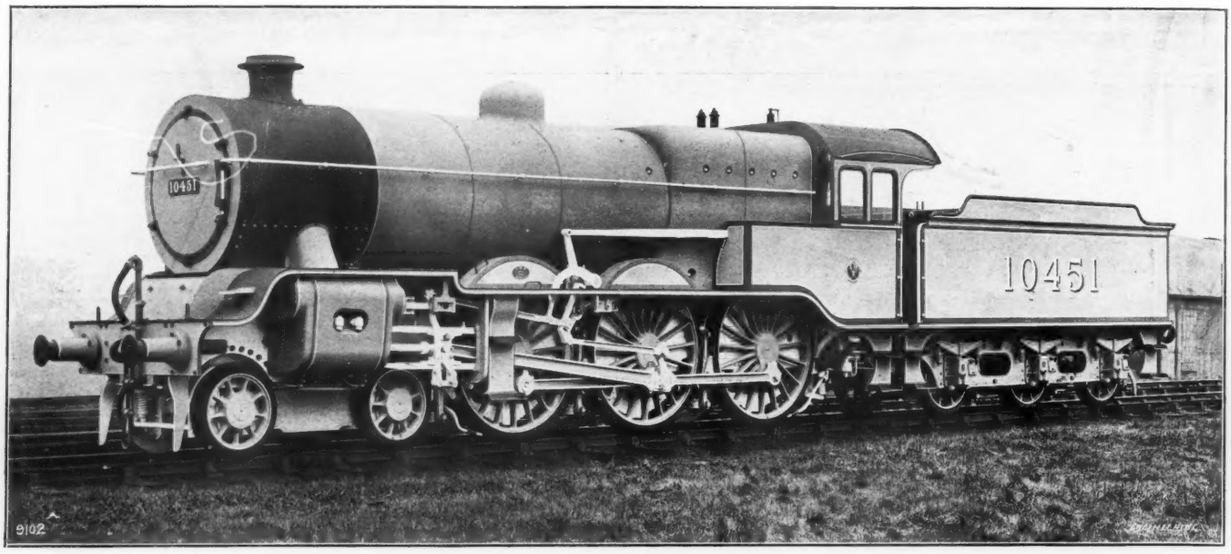
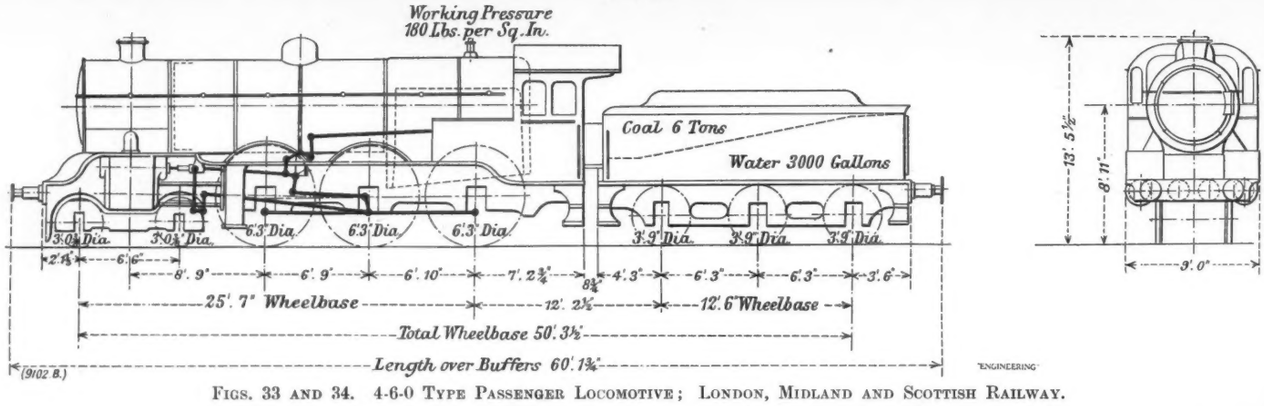


FIG. 33.



FIGS. 33 AND 34. 4-6-0 TYPE PASSENGER LOCOMOTIVE; LONDON, MIDLAND AND SCOTTISH RAILWAY.

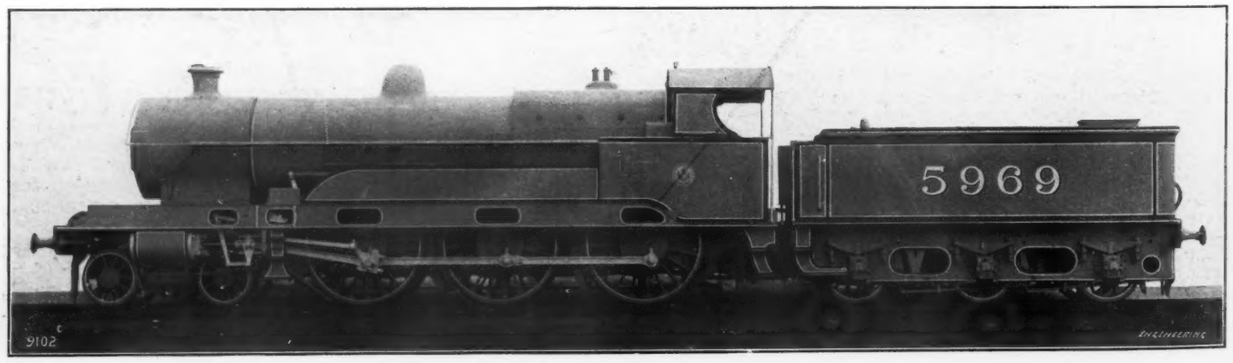
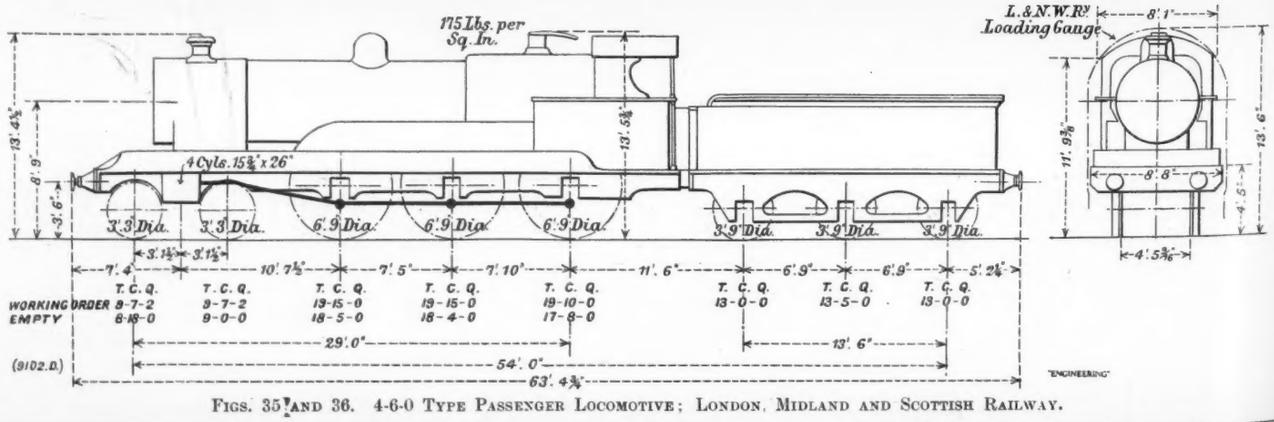


FIG. 35.



FIGS. 35 AND 36. 4-6-0 TYPE PASSENGER LOCOMOTIVE; LONDON, MIDLAND AND SCOTTISH RAILWAY.

THE CENTENARY OF PUBLIC STEAM RAILWAYS.

(*For Description, see Page* 783.)

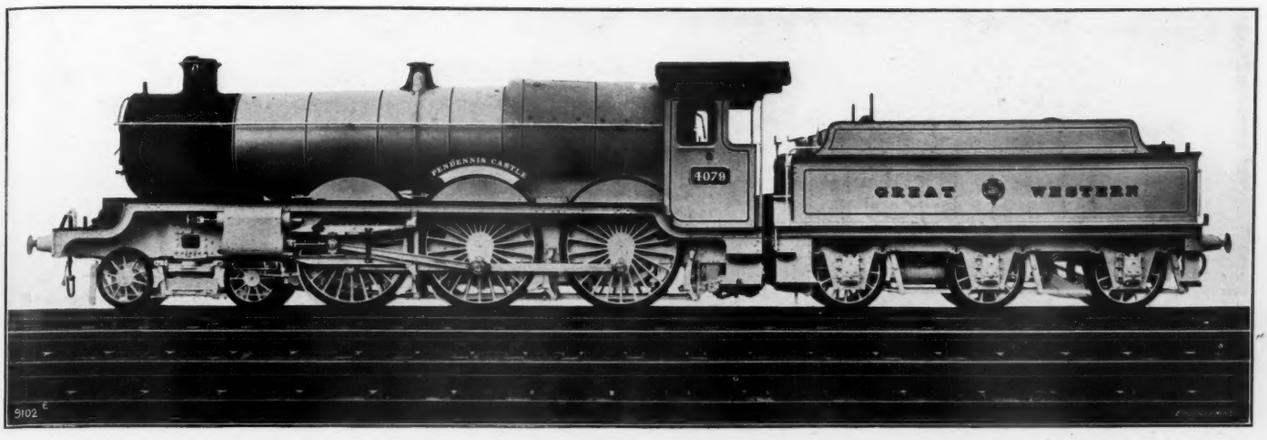
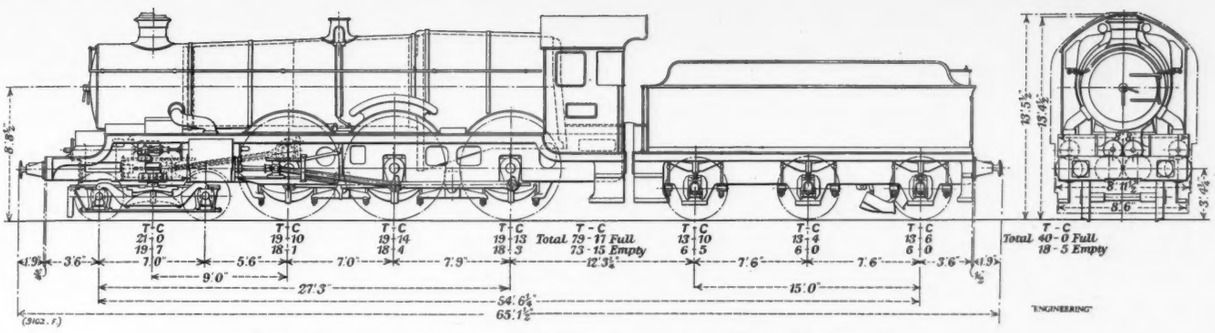


FIG 37.



FIGS. 37 AND 38. 4-6-0 TYPE PASSENGER LOCOMOTIVE; GREAT WESTERN RAILWAY.

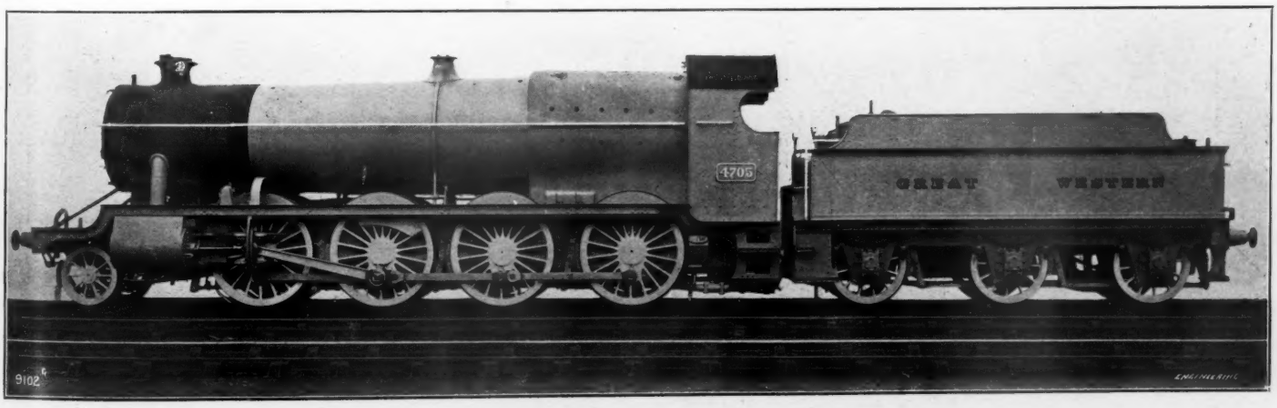
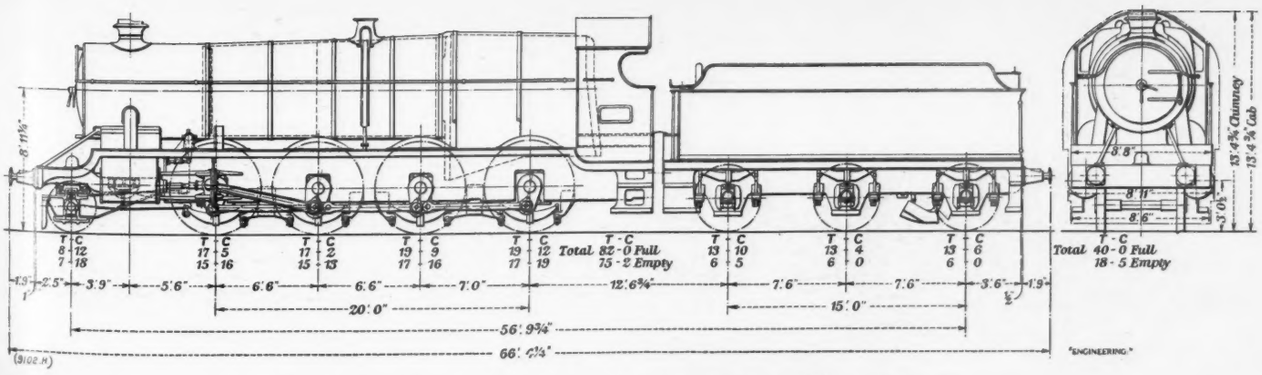


FIG. 39.



FIGS. 39 AND 40. 2-8-0 TYPE FREIGHT LOCOMOTIVE; GREAT WESTERN RAILWAY.

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(For Description, see Page 783.)

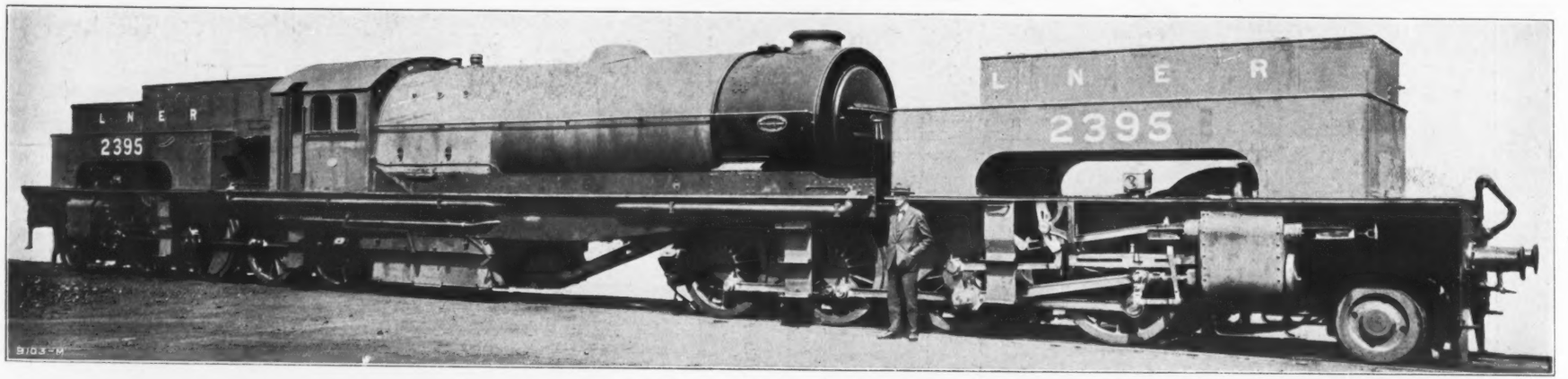

FIG. 41. 2-8-8-2 TYPE GARRATT LOCOMOTIVE; LONDON AND NORTH EASTERN RAILWAY, 1925.

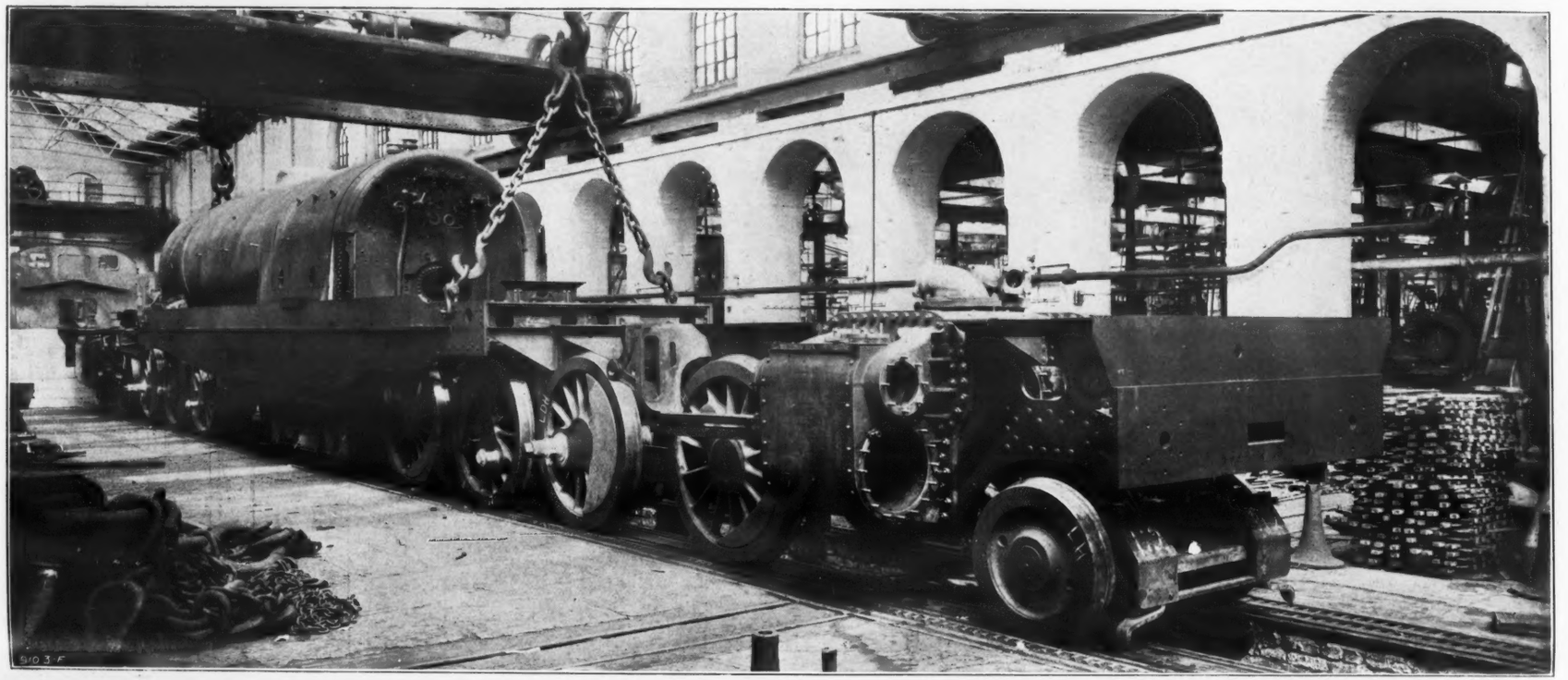

FIG. 42. 2-8-8-2 TYPE GARRATT LOCOMOTIVE IN COURSE OF ERECTION.

(To face page 791.)

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

All accounts are payable to "ENGINEERING," LTD. Cheques should be crossed "The National Provincial Bank, Limited, Charing Cross Branch." Post Office Orders should be made payable at Bedford Street, Strand, W.C.2.

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TASMANIA: Gordon & Gotch Prop'ty, Ltd., Launceston: Hobart.

UNITED STATES: For Subscription, New York: W. H. Wiley, 440, Fourth Avenue. For Advertisements: J. S. Allan, 30, Church Street, New York.

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ENGINEERING.

FRIDAY, JUNE 26, 1925.

TRANSPORT.

THE differences, due to the advances which have been made in the practical applications of physical and chemical science, which distinguish this age from any that has gone before are obvious and manifold. Their complexity is almost beyond analysis. There is, however, one specific manifestation of these advances which, on broad lines, is simple enough, and which probably more than anything else is characteristic of our times. This is the development of transport. In the sense that the advances have been more revolutionary, the improvement in the means of sending messages to a distance may appear a more striking development, but actually the effect of these changes on the material development of the world is relatively small compared with the effect of the progress in the means of transport. While much of the telegraphic and telephonic communication which is so interknit with modern life is an aid to the material activity by which that life is rendered possible, even more is of but an incidental and diverting quality. While it is amusing to know the result of a cricket match in Australia and interesting to hear of the development of labour troubles in China, neither has the practical bearing on the mere carrying on of modern life that has, say, the shipping of rice from Rangoon to Valparaiso or the transport of china clay from Cornwall to the Potteries.

It is probably not usually realised to what extent the present-day world lives by means of transport and owes its existence to it. Those who are critical of their own age and plead for a simpler life show, as a rule, no reluctance to take advantage of the facilities which our complicated civilisation affords. Even the extremists who cry out for a return to nature are usually quite prepared to eat Jamaica bananas and Canadian apples and to clothe themselves with textiles for which the raw materials have to be collected in America, Egypt and Australia. A simpler life is possible and has been lived in these islands, but a return to it would eliminate most of the everyday commodities and services which are now taken as a matter of course. Without transport, life as we know it could not be carried on, and it is transport more than anything else which has made that life possible.

Transport is not static any more than the other material activities of modern days, and the last twenty years have seen very remarkable advances in most of its branches. These advances have been concerned in the main with road and air transport, although very considerable progress has also been made both on railways and at sea. Air transport has as yet, however, had but little effect on the everyday activities of the ordinary man, and need not be treated as an important item in any attempt to trace the dependance of civilisation on transport. Road transport is more closely concerned, and in many countries is an important aid to, or competitor with, railways, depending on the point of view. Leaving this aspect of modern transport aside for a moment, it is safe to say that railways and shipping form the essential connecting links holding together and transmitting the energy of modern civilisation. The sailing of ships is an older art than the running of railway trains, and great as have been the developments of shipping in the last century, it is probable that their effect on the progress of the world has not been so great as that of railways. The contrast between the shipping methods of a hundred years ago and modern methods, enormous though it is, is not so great as that between the land transport methods of the two periods. If we were to lose both railways and steamships, and to revert in the sphere of both to the methods of the eighteenth century, shipping would be much better able to cope with the problem with which it would be faced than would the pack horse and wain in the allied sphere.

With transport in a state of almost feverish development, there is, in a sense, no justification for taking any point as marking the end of a period and calling for retrospect. None the less, as it would be impossible to get the public to take any interest in, or indeed any notice of, an attempt to celebrate and call attention to the enormous part which mechanical transport takes in modern life, unless the proceeding centred round some point or incident, there is every justification for taking the hundredth anniversary of the beginning of the first public steam-operated railway as such a point meet and favourable alike for retrospect and stocktaking. It is to be hoped that the celebrations of next week will bring to the general public some faint idea of the extent to which its very existence is conditioned by and is dependant on transport, and very especially, railways. We pay our tribute elsewhere in this issue to this important Centenary, and need not attempt to deal with it here, while the more modern technical developments which are of interest only to the technical man will receive much attention in the reports of the meetings of the International Railway Congress, of which the first also appears in this issue. Further matter of this kind will be afforded by the two important papers which are to be read before the Institution of Mechanical Engineers at its summer meeting, to be held in Newcastle, the week after next, and with which we shall deal in due course.

The incidents of this week form a suitable occasion for some speculation on the future of transport generally, and particularly on the future of railways. We are not here concerned with the technical details of methods, and in the sphere of shipping need not discuss any question of the relative merits and prospects of oil engines and steam turbines. From our present wide angle, the question of shipping arises only in relation to its competition with aircraft. From the commercial point of view, the latter is as yet little more than an experiment, although few can doubt but that such services as that between London & Paris will take a permanent place in transport methods. Long-distance travel by air-ship is in a different case, and while the advocates of services to such countries as India and Australia, lay much stress on the saving in time which is promised, it is but fair to the shipping interest to point out that the present speed of travel to these countries is as yet far from the maximum possible by sea. One may assume that the present sea speeds are settled by commercial considerations and that if the demand ultimately justifies it, those speeds will be materially increased.

The chief new competitor of the railway is certainly the road vehicle, although the aeroplane is also a competitor with it as with the steamship. In such a service as that between London and Paris

1925.

FIG. 42. 2-8-8-2 TYPE GARRATT LOCOMOTIVE IN COURSE OF ERECTION.

the aeroplane has one advantage in that no change of vehicle is necessary in the mixed journey over land and water. The development of train ferries may possibly ultimately give the railway the same advantage, while again, if commercial conditions justified it, the time of the journey by rail could certainly be considerably reduced. In no event, however, is the railway likely to be able actually to equal the speed of the aeroplane any more than the steamship is likely to equal the speed of the airship. The ultimate victory of one or the other is in both cases purely a commercial question, and present experience suggests that in each service sufficient special traffic will offer itself for the fleeter service to win at least a permanent footing.

From the railway point of view the question of aeroplane competition is, however, at the moment a comparatively incidental matter. The subject of real interest is that of the future magnitude of road transport. This question has assumed considerable importance in this country, owing to the development of the commercial vehicle and the excellent roads which are provided for its service. It is chiefly in goods transport that the matter has assumed importance for the railway companies. Leaving aside ordinary suburban transport in large towns, which introduces questions of railway electrification and cognate matters with which we are not now concerned, it cannot be said that passenger service by road has developed to any important extent. There is, of course, a moderate amount of road transport by private motor-cars which represents a loss to the railway, but transport by chars-à-bancs or omnibuses shows at present no signs of establishing itself over any considerable distances. In the matter of time only does the long-distance char-à-banc appear to have any advantages over the stage coach; and the remarkable facilities and conveniences during travel which have been developed by the railways in the last 50 years or so are as yet not challenged, or even imitated, by any form of road transport.

In goods traffic the road takes a more important place, and in certain spheres goods services over considerable distances have been established. Matters are, however, still on a relatively small scale. Goods traffic of all kinds is conditioned to a very large extent by terminal facilities, and it is in its ability to serve any terminal that much of the advantage of the commercial road vehicle lies. This adaptability to any terminal is, however, to some extent a disadvantage in connection with the heavier freight services and it is, for instance, difficult to imagine that any form of road vehicle could show any advantage over the railway in handling, say, export coal from the South Wales field. The railways are certainly likely to retain the main freight services of the country as distinct from the handling of comparatively small parcels of goods. In this country, however, they will probably never be able to handle such freight services as effectively as is done in, say, the United States, owing to the limitations imposed by the loading gauge. As Sir Henry Fowler pointed out in his lecture at the Conversazione of the Institution of Civil Engineers last week, the railways have to be thankful for the fancy coaming which Stephenson put at the top of the funnel of the Rocket, and which is well shown in our illustration of this machine on Plate XLIX. The loading gauge was fixed to clear this coaming, and has remained fixed ever since. One may share Sir Henry's regret that Stephenson did not also put some frillings on the side of his locomotive, and so give us a little more room in that direction also.

THE MICROSTRUCTURE OF A COAL SEAM.

A CHIEF difficulty felt by users as well as owners of coal, lies in its varied composition, sometimes when it is derived from a single colliery, or even a single seam. Some users on a large scale are disposed to deny the advantage of inquiring into the distribution of differences in composition if they can be averaged over a carload or larger quantity. How far this attitude is justified when the coal is burnt raw for the mere production of heat, as in a power-station, is open to question; but no question can arise with coal that is to be broken up into constituents of which the technical value will depend on their composition. For such uses the distribution of the differences in various constituents may be of considerable consequence to the advantage with which the coal can be used, and a knowledge of whether an element is distributed uniformly over a deposit or is concentrated in a thin layer may make all the difference to the efficiency with which the several parts of the deposit may be applied to the uses for which they are respectively most suitable.

The recognition of the importance of such knowledge has led to the institution of the Physical and Chemical Survey of the National Coal Resources, now being conducted by the Fuel Research Board with the co-operation of local committees in various coalfields, by which not only the situation and extent of deposits are being recorded, but also their composition and their behaviour in such typical circumstances as will define the uses for which they are best adapted. The investigations made in connection with this survey have already brought to light the abruptness with which seams will change their character and composition, and in at least one instance have shown how a coal that would have been excellent for making metallurgical coke but for its high sulphur, might be used satisfactorily for that purpose by rejecting and leaving underground a thin band in which the sulphur was concentrated. To obtain such results is, however, a circumstantial business, involving a great deal of work and no great certainty as to how often it must be repeated along the course of the seam; and advantage might obviously result if alternative methods were available for obtaining such and similar information.

Up to now the usual methods have been chemical, taking the coal as a substance to be analysed like any other mineral. In an alternative aspect, however, coal may be considered from the point of view of its vegetable origin. Though it appears to-day as a complex mineral, it was originally formed from a large number of kinds of vegetable growths, with all the complexity of botanical formations, complicated still further by mineral intrusions. When thin sections of it are cut, they show much of the structure of the growths that it contains, and, as yet, it is uncertain whether an intimate knowledge of the disposition of these growths in the mass of the seam may or may not have a useful relation to the character of the coal or to its behaviour after it has been raised. This uncertainty is due to the fact that enough is not known of what such sections disclose, and the situation is thus eminently one that calls for purely scientific research, pursued for the express purpose of perfecting available knowledge of the structure in question, and leaving the applications of such knowledge, if any should be found, until the knowledge itself has been acquired. This view has been adopted in the Coal Survey, and a considerable amount of investigation has been going on for some time at the Lomax Palæo-Botanical Laboratories of the Lancashire and Cheshire Coal Research Association, with assistance from the Department of Scientific and Industrial Research. To slice as brittle and incoherent a substance as coal into sections thin enough to be examined by transmitted light, is a delicate operation, which has been perfected mainly by the work of Mr. James Lomax: and in addition to sections of particular specimens, a systematic examination is going on of sections of seams in a number of coalfields. Already in 27 localities in Lancashire, Yorkshire, the Midlands and South Wales, sections have been cut of complete coal seams layer by layer from floor to roof, and have been deposited at various central institutions where they are available for inspection.

To indicate the scope of the work and the nature of the information it yields, the Fuel Research Board have now published a report by Mr. James Lomax, on one of these examinations.* It describes and illustrates the work done on the Lanterne seam of the South Wales coalfield, the 91 illustrations being reproductions of transparent sections under a magnification of 20 diameters, with a frontispiece in natural colours under a magnification of 50 diameters. The reproductions are in collotype, so that they can be examined under a magnifying glass, and—a considerable convenience for a work of this kind—the report is bound in cloth. Most of the sections are taken in pairs, one horizontal and one vertical, and at about the same point. The seam in the locality where the sections were cut is some 3 ft. 8 in. thick, and is divided into 13 horizontal blocks, including the seat earth, the sections being taken at intervals of about an inch. When marked change in the structure of the coal was observed, an additional special horizontal section was prepared in that region. The sections appear under the microscope in various tints from light yellow to deep amber and red, partly according to the thinness of the slice and partly according to its ingredients. They show not only plant structures preserved in the mass of the coal, but also in some views the types of varieties of coal according to the modern classification. The clearness with which some of the structures appear is remarkable. In particular, some radiating formations may be seen, which are thought to have a possible bearing on the disintegration of coal after it is raised. Taken altogether, the micro-photographs show a variety of structure far beyond what could be suspected from a naked eye examination. They correspond, however, to what would be expected when the formation of the coal from vegetation is considered. What sort of relations, if any, will emerge between the structure of the coal so revealed and its chemical and physical characters cannot perhaps yet be conjectured. What the report shows is that the variety of structure of coal is vastly beyond anything of which account has hitherto been taken in practice. Whether ultimately such account will be able to be taken or not is at present an open question; but no doubt can be felt that in the face of such remarkable variations in structure and of means so efficient as these in cross-sections for displaying it the inquiry is one that ought to be pursued.

* Technical Paper No. II. The Microstructure of a Coal Seam. H.M. Stationery Office. [4*s.* 6*d.* net.]

THE INTERNATIONAL RAILWAY CONGRESS.

ALTHOUGH it had been decided at the Railway Congress at Rome in 1922 that the next meeting would be held in Madrid in 1927, it was arranged later to participate in the celebration of the centenary of the introduction of railways and hold a congress in London this year. That this was acceptable to the members was manifest by the very large number who took part in the proceedings which opened in the Great Hall of the Institution of Civil Engineers, Great George-street, Westminster, on Monday last. These meetings constitute the tenth congress, the first being held in Brussels in 1885, when the jubilee of the Belgian railways was celebrated. The later conferences were held in Milan (1887), Paris (1889), St. Petersburg (1892), London (1895), Paris (1900), Washington (1905), and Berne (1910). A Congress would have been held in Berlin in 1915 but for the European war, when all the activities of the International Railway Congress Association were suspended until the evacuation of Belgium by the Central Powers.

At the opening meeting of the Congress on Monday, June 22, H.R.H. the Duke of York was received by M. E. Foulon, of the Belgian State Railways, and President of the Permanent Commission of the Congress, Viscount Churchill, Sir Guy Granet and Mr. William Whitelaw.

The Duke of York then welcomed the delegates on behalf of His Majesty King George and H.R.H. the Prince of Wales, the President, to, what he termed, the birthplace of railways. Continuing, the Duke referred to the historic occasion of their meeting, the centenary of the inauguration of the Stockton and Darlington Railway. To this country belonged the honour of setting an example of progress, which other nations were not slow to follow, and the development of the railway systems of Europe and the opening up of the vast American Continent by railway enterprise were among the wonders of history. Conferences such as these, he said, through the propagation of knowledge and exchange of experience, played an important part in the progress of the world. They also served to

provide an opportunity for the representatives of every nation to meet on a common ground, to get to know each other better and to appreciate each other's point of view.

M. E. Foulon then expressed the gratitude of the Congress to the Duke of York for presiding at the opening session. When their British colleagues approached them with the suggestion of holding the present Congress in London in this year of celebration, he said, the Spanish Government consented to the postponement of the Congress in Madrid to 1930, and agreed that it was desirable to participate in the centenary of the opening of the first railway line in the world, used for public traffic. The invention of George Stephenson was of all, the greatest in its influence upon the lives of nations and on the growth of civilisation. To-day there were 7,600,000 miles of railway line and there had been a progressive development in respect of speed, acceleration and reliability. They were assembled to pay homage to George Stephenson and the country of which he was one of the most illustrious sons.

The Congress was, he continued, divided into five sections and these concerned: I, way and works; II, locomotives and rolling stock; III, operation; IV, general questions; and V, light and Colonial railways. The principal questions which would be discussed were the methods of maintenance and repair of track, the initial causes of breaking of rails, the lay-out of shunting and marshalling yards, reduction of the cost of traction, high speed electric locomotives, despatch and control systems, signalling for lines with dense traffic, the eight-hours' day and the means of establishing light railways for opening up transport in new countries.

Lieut.-Colonel Wilfrid Ashley, H.M. Minister for Transport, in extending the welcome of His Majesty's Government to the Congress, said that the outstanding characteristic of the scientific man was his desire to communicate whatever knowledge he possessed, to the general store and so make progress universal. In the forty years of its existence the International Railway Congress Association had continuously increased in strength until to-day there were no less than 235 railway administrations represented in its membership. The importance of reducing transport costs to a minimum could hardly be over-estimated and mutual discussions on this question would prove very helpful.

Viscount Churchill, Chairman of the Great Western Railway, then offered the cordial welcome of the British railway companies to the delegates.

After the Duke of York left the meeting M. E. Foulon took the chair and expressed the thanks of the delegates at the Congress to Lieut-Colonel Wilfrid Ashley and Viscount Churchill. He then proposed the election of Colonel Ashley as an Hon. Vice-President of the Congress and also nominated Viscount Churchill as acting President for the Session.

Viscount Churchill on taking the chair invited the chief representatives of each adherent Government to act as vice-presidents and proposed that M. Ghilain and Sir Henry Fowler be appointed general secretaries. These proposals were accepted unanimously. He then referred to the progress of railways during the hundred years of their service and the influence that their development has had on the trade of the world and the spread of civilisation.

A delegation then proceeded to the Cenotaph in Whitehall, to place a wreath there on behalf of the Association.

On Tuesday morning, June 23, each of the five sections met to elect their office-bearers and to determine the procedure to be adopted in dealing with the subjects of the various reports. The members who were chosen to act as Presidents were Mr. E. C. Trench, Vice-President of the Institution of Civil Engineers and Chief Engineer of the London Midland and Scottish Railway in Section I; M. Weiss of the Swiss Federal Railways, in Section II.; M. du Castel, ex-Director-General of the Ministry of Public Works in France, in Section III.; Dr. Parmelee, of the American Railway Association, in Section IV.; and M. Semenza, Italian Government delegate, in Section V.

Shunting Yards.

Sections I. and III. then held a joint meeting to discuss the reports prepared by Messrs. W. Simon-Thomas, S. T. Wagner, R. H. Nicholls, A. Moutier and E. Pellarin, on the subject of "Shunting Yards."

In his report on the question of shunting yards in Great Britain, her Dominions and Colonies, Mr. R. H. Nicholls, of the Great Western Railway, stated that the insistent demands for increased and quicker transportation facilities were causing British railway goods-marshalling yards to be in a constant state of development. Changes in design and organisation were continually being made in consequence, and, for this reason, the advantages of modern, as compared with older methods, could very readily be judged in this country.

Questions of site and location were naturally of vital importance. The principal factors involved in the ideal lay-out of yards consisted of the following: reception lines upon which freight trains could be received whilst waiting to be shunted; sorting sidings into which wagons for various destinations could be shunted and departure lines on which trains could be placed when made up. Of all the gravitation shunting methods in operation in the British Empire the summit, or "hump" principle was the most efficient and economical. Hump shunting was quicker, less costly, and entailed less risk to shunters and less damage to wagons than flat shunting. It had not been found necessary to have humps of varying heights to meet changes in weather conditions, although in some cases the summit was repacked for the winter in order to obtain a faster descent. The maximum speed of a wagon after leaving the top of the hump should not exceed 10 m.p.h. to 12 m.p.h., and this was generally obtained by a fall of 5 ft. by a gradient of 1 in 30. A considerable proportion of most train loads was carried in privately-owned wagons fitted with grease axle-boxes, and the fact that these had to be moved with the faster ones fitted with oil axle-boxes constituted a difficulty. The weight of wagon contents also affected shunting speed.

The placing of up and down yards on separate sides of the line was not economical and, wherever practicable, they should be on the same side of the main running road. It was distinctly advantageous to have locomotive sheds, yardmaster's office and other buildings and premises in as central a position in the yard as possible.

The similarity between British and American shunting yard practice was evidenced by the report presented by Mr. S. T. Wagner, chief engineer of the Reading Railroad Company of the United States. Hump yards were the type most generally used in America, although "poling" yards requiring a very extensive lay-out had also found favour. In the latter system, the movement of cars during shunting was accomplished by the use of a pole attached to an engine on an adjacent parallel track. The old type of flat yard was only used where business was relatively small or where a more elaborate lay-out was impossible.

On all roads where conditions allowed it to be used, the hump yard had become the standard type. The summit shunting yard of the Chicago Union Transfer Railway Company at Chicago was over 2·5 miles long, contained 105 miles of track, and was capable of holding 14,000 wagons. It was probably the largest yard of its kind in the United States. The hump system of shunting was specially adapted to goods stations in which a large volume of business was handled. Summit profiles were made much steeper in cold climates than in temperate or hot climates. In the first case, the total fall recommended amounted to approximately 8 ft. 3 in. in 345 ft.; in the second, for temperate climates, the downward slope was approximately 7 ft. 1½ in. in 345 ft. For hot climates, the total fall measured 5 ft. 2 in. in 345 ft. When necessitated by climatic conditions, the hump was increased in winter by raising the track and was restored to its former height during the summer months. On one railway, low summer and high winter humps had been established upon parallel roads. Track scales were used in hump yards for weighing cars whilst in motion. They usually had a capacity of 150 tons, were from 50 ft. to 60 ft. in length, and were ordinarily placed at a distance of 100 ft. to 150 ft. from the summit of the hump. The moving cars were thus running at a speed slow enough to secure correct weighing.

The majority of the large shunting yards were so arranged that the main running tracks were located on each side of the yard. In some cases, however, the main tracks ran through the centre of the yard. The former arrangement was preferable, principally because shunting operations could be conducted without interfering with the main line traffic.

The report dealing with Spanish, Swiss, Italian, Swedish, Danish, Portuguese, Finnish, Norwegian, Dutch, and Czecho-Slovakian railway shunting yards, prepared by Mr. W. Simon-Thomas of the Dutch Railways, was a very elaborate one. Two types of yard were in use, the hump and the "continuous gravitation" type. The latter could only be recommended in places where a natural gradient existed, and was specially applicable to those yards, in which shunting was in one direction only. Hump yards had been constructed on most European railways and, in many cases, winter and summer humps of unequal heights were provided. It was advisable, however, that the radius of curvature of summits should be such as to enable wagons to reach any point on the sidings, even under unfavourable weather conditions. For this purpose, the hump should consist, as far as possible, of only one single steep gradient and, when rendered necessary, the speed of wagons should be reduced by means of a rail-brake. Several types of automatic rail-brakes had recently been introduced. That constructed by the firm of Willman & Cie., acted on the outer and inner vertical faces of the tyres by means of brake-rails, the pressure exerted could not, however, be adjusted. Mr. Lohse had improved this arrangement by making the brake pressure adjustable by means of hydraulic gear. The Thyssenhütte brake system, invented by Dr. Frölich, in 1921, was in use in several yards on the Continent, and had given noteworthy results. In this system the pressure which acted on the two sides of the wheels was a function of the weight of the wagons. The Frölich invention consisted of two brake-rails arranged alongside the track rail and connected at distances of about 9 ft. 2 in. by shoes sliding on a horizontal support, which could be raised vertically by hydraulic pressure. The internal brake-rails rotated on the bearing levers about an axis inside the shoes. The flanges of the wagon wheels entering the brake, when this was raised, bore on the flanges of the inner brake rails. These rails turned about their axes, and the wheels were pressed from both sides as in a vice between the heads of the brake-rails. The force with which the hydraulic plunger raised the brake-rails was equivalent to 10 metric tons. The greater the total weight of the wagon running over the brake-track, the greater was the action of the brake-rails. The pressure could be taken off at any moment by means of a lever. With one of these appliances it was possible for a skilful employee to so control shunting operations as to increase the output of the hump yard very appreciably.

The general organisation of a shunting yard and the disposition of repair shops, coal stores, locomotive sheds, water supplies and the like, were matters of great importance, and the lay-out should be such as to give maximum efficiency in coping with the volume of traffic. The possibility of future enlargements to deal with increased business should always be borne in mind.

After an exchange of views by the delegates, it was decided to submit the following proposals for acceptance at the general meeting:—That the use of shunting and marshalling yards increased the rapidity of transport, the capacity of the lines and the movement of rolling-stock. The lay-out must depend upon the organisation of the traffic in through, semi-through and stopping trains in accordance with its importance and distribution. In length these yards may be as much as 3 miles, and they would consist usually of reception sidings, sorting sidings, and frequently of sidings where goods could be separated according to destination. There should also be sidings for trains preparing for departure and some transfer sheds. To be quite complete there should be a wagon repair section, a

locomotive shed and a disinfecting yard provided. Yards might be established to make use of gravitation either with continuous gradients or on a level with a hump, according to the local conditions and the contour of the land available. A group of shunting sidings for each direction was advisable when the traffic in each direction was more or less independent, otherwise a single group of sidings was preferable. This was also the case when the number of wagons to be split up daily did not exceed the capacity of the hump. Careful arrangement was necessary to carry out the preliminary operations of splitting up the trains so that no undue delay was caused. In the operation of splitting up trains the indications of the sidings to be used should be given to the pointsman and to the shunting staff in a clear and simple way, equally capable of being used by day or night or during foggy weather. For this purpose shunting tickets, loud-speaking telephones, luminous signals and electric push buttons at the hump were put to service in various installations. When it was necessary to have a shunting engine, communication must be possible between the driver and the foreman shunter and pointsman. As the influence of wind resistance was considerable, the splitting-up sidings should be arranged in the most favourable direction in relation to the prevailing winds. The radius of curvature at the top of the hump should be at least 10 chains. One or two points were left over for discussion in later sessions.

FUEL AND ITS COMBUSTION.

After a few introductory remarks by the President of Section II of the Conference at the meeting on Tuesday morning, June 23, he called upon Mr. Bulleid and M. Minsart to read a summary, in English and French respectively, of a report prepared by Mr. G. H. Emerson, of the Baltimore and Ohio Railroad, on the subject of "Fuel and its Combustion."

In this report it was stated that the availability of coal in adequate quantity and at comparatively low cost in extensive areas in America explained its practically universal use as locomotive fuel. High-grade coal was used and the mixing of higher- with lower-grade coals was not usual practice. Low grade fuels such as peat or lignite had not found favour owing to their lower heat values and the difficulty of realising this heat value without greatly increasing the grate area of the fire-box. With regard to pulverised coal, some few tests had been made with the object of ascertaining its practical usefulness as a locomotive fuel. Difficulties had been encountered, but on the whole, the results obtained had proved successful. For economic reasons however the process had not been adopted. Colloidal fuel consisting of pulverised coal stabilised in mineral oil had been experimented with. The fuel was atomised and was burned as fuel oil, using the ordinary pre-heat system of the latter. The trials carried out had demonstrated its worth as a fuel for various marine and land purposes but up to the present it had not been adopted upon a locomotive.

Oil was being utilised to an increasing extent as a locomotive fuel especially by those railways passing through or situated close to oil fields. Nevertheless, no matter how companies were in a position to control their coal supply by mine ownership and other means, the same could not always be said of oil supplies. The present period of great production and low prices would undoubtedly be followed by one of decline of production and correspondingly increased prices, unless new fields with large outputs were discovered. Companies using oil fuel reported the use of seven makes of burner of two distinct types, the external atomiser and the internal atomiser, all being situated at the front end of the fire-box. Air opening varied from 26 to 40 per cent. of the net flue area and was arranged around the burner and at the bottom and sides of the pan.

With reference to grates it was stated that in a few cases only had investigations been made on the proper air opening, and that in practically no instance had any attention been paid to the grade of cast iron used. Theoretically, there was no limit, from a combustion standpoint, to the air opening which could be used with advantage. One railway, which was experimenting with a grate of the non-interlocking cross-rocking finger type, in which an air opening of slightly more than 50 per cent. was employed, had obtained results which, although at present incomplete, tended to indicate that combustion conditions were much superior to those obtained with their standard grate, which gave a 36 per cent. air opening. The rival merits of interlocking and non-interlocking grates were, however, open to discussion as were those of table grates and finger grates. The material used in making grates should be cast-iron of maximum strength commensurate with toughness, small shrinkage and high melting point.

Much progress had been made during the past 20 years in the development of mechanical stokers, and the International Railway Fuel Association Committee on Firing Practice had given the matter serious attention. The advantages gained consisted principally in the development of greater locomotive capacity, and ensured good fuel distribution, reliability in operation and facility of maintenance.

Appliances for smoke combustion had been subjected to elaborate tests in 1912 and 1913, but no further research had since been made. Various methods were in use on several railways, but in many cases no special appliances for the suppression of smoke were utilised.

The report drawn up by Mr. C. B. Collett of the G.W.R. upon the subject of Fuel and its Combustion with reference to the railways of the British Empire stated that all the administrations in the United Kingdom used coal fuel. Two colonial railways utilised oil over certain sections of their lines. Pulverised and colloidal fuels had been used experimentally but were not considered a commercial proposition. Peat and lignite had not been utilised as fuels. The purchase of coal was generally accomplished by fixed price contracts over periods of from 3 to 12 months. Coal stacking in the open, with about 3 months supply maintained as stock at the various depots, was the usual procedure adopted. The majority of the railways purchased their fuel within their own districts whenever possible. Some administrations mixed coals coming from different sources, but this process was usually based upon practical experience of the coals used and also on data obtained from laboratory tests. None of the British administrations was using rocking grates, although several of the Colonial companies had experimented with them with success. In the case of the Canadian National Railways all the grates were of the rocking type. The firebars used on English railways were generally made of cast-iron sand-cast in preference to chill-cast, and the air space between the neighbouring bars varied from $\frac{1}{16}$ to $\frac{1}{8}$ of an inch. Sloping grates were the rule in British practice and it was stated that no difficulty had been experienced in maintaining a good fire at the back of the firebox. Generally speaking it had been found that inclined fire-bars required slightly more frequent renewals than had been the case with horizontal grates. The only administration having any experience of mechanical stokers was the Canadian National undertaking, all other railways still used the hand-firing principle.

While some railways had done little in the matter of smoke reduction, other organisations had fitted to their engines fire-doors specially designed for the purpose. Spark arresters had been tried on many railways, but some differences of opinion existed as to their effect on the draught on the fire and their actual value in preventing fires.

In conclusion, the reporter stated that the replies received had not on the whole revealed any very outstanding change in modern practice. No definitely practical form of boiler construction, which would ensure a greater evaporation per pound of coal than had hitherto been obtained from locomotives for some years past had been suggested.

M. Chenu then presented his report on the same subject relating to countries other than the British Empire and America. In this it was stated that railways could be classified according to the regulations they adopted regarding the fuel supplied to them. In the first group there were those of which the engineers attached importance to the source from which the coal was obtained, and in the second were the cases where special conditions were specified as to the nature and characteristics of the fuel. Such factors as size, percentage of volatile matter, ash content, amount of moisture, percentage of sulphur, caking capacity, and, in the case of briquettes, the percentage of pitch and the degree of friability, were amongst those selected for strict specification. Sometimes a guaranteed calorific value was also stipulated. M. Chenu pointed out that the consumption of fuel on different railways could not be compared owing to the statistics being prepared in different ways, and suggested that it was desirable that standard statistics of fuel consumption based on calories per virtual ton-kilometre should be adopted.

The President, M. Weiss, suggested that the reports should be discussed together, but in two parts, namely, fuel and the means for dealing with it.

M.M. Lacoin, of the Chemin de Fer Paris à Orléans, agreed that a new and rational basis was needed for fuel statistics, and suggested that the consumption of coal per driver should be by virtual ton-kilometre. The experience of the Portuguese Railways in the use of this method was then referred to by M. P. J. Diniz, who stated that it had been the means of obtaining a reduction in consumption. Further reference to the same subject was then made by M. G. Bianchi, of the Italian State Railways, who said that the method had been used on their lines for at least twenty years. The formula they used to calculate the coefficient, which averages about 1·35, was based on the resistance of rolling stock and took into account the grades and curved only, no allowance being made for speed. Sir Henry Fowler then suggested that the question of standard statistics should be brought up at a future session in view of its importance.

M. Cantuniar, of the Roumanian Railways, dealt with the use of oil fuel. He found that the best results were obtained with a mixture of oil and lignite, as this caused less damage to the fire-boxes than oil alone. There was still room for an improved burner. He preferred the external burner, but thought a burner with a fixed ratio of oil and steam for each desired output was necessary. The only modification to the boiler was the removal of the grate and the lining of the sides of the fire-box with brick. M. Nobili, of the Italian State Railways, reported that a three years' test has been made by them and that it was found that oil alone gave the best results. In their case the burners were placed at the back of the box. They had overcome the variations in temperature by the use of a number of burners, up to as many as five.

M. A. Pawlowski, of the Ministry of Railways, Warsaw, asked for the experience of the delegates with rocking grates and drop grates, as the matter was of great interest to those systems which had to use coal with a high ash content. In reply to this request, Colonel F. R. Collins, of the South African Railways, stated that all his locomotives were fitted in this way and had given every satisfaction with such coals. This comment was endorsed by Mr. E. W. Head, of the Ceylon Government Railways.

The President then called attention to the fact that the efficiency of smoke-consuming devices depended upon the driver to a very large extent. He noted that there was little smoke in England where no such apparatus was fitted. Many of the Belgian locomotives were provided with smoke-consuming arrangements, but when carelessly handled these engines emitted a considerable amount of smoke.

When the session was resumed on Tuesday afternoon Mr. D. F. Crawford opened the discussion by referring to American experience with mechanical stokers. There were, he said, 8,000 stokers now in use, representing 15 per cent. of all American locomotives and 90 per cent. of those of 60,000 lb. tractive effort or more. When the grate area was 45 sq. ft. or over they were generally in use. The results obtained had proved to be highly satisfactory. The reason for fitting mechanical stokers was to get over the necessity for a second fireman on the larger locomotives. With them in use it was found that they obtained a higher temperature in

the fire-box than was the case with hand-firing. Stoker-fitted engines could handle trains of 10 to 15 per cent. increased weight over what was possible with hand firing. In answer to a question by M. Lacoin on economy, Mr. Crawford said that economy was not looked for, but undoubtedly was obtained owing to the better firing. Sir Henry Fowler then asked for a statement regarding any possible effect on the superheat, and Mr. H. N. Gresley sought information on what was regarded as the maximum number of pounds of coal per hour which could be fired by hand. The superheat was increased, said Mr. Crawford, but he could not give any definite figures. The maximum rate of firing was 4,000 lb. per hour and above this figure a mechanical stoker was used to avoid having a second fireman.

Axle-Boxes and Lubrication.

Consideration was then given to three reports on the question of reducing the cost of traction from the point of view of the lubrication of axle-boxes of all rolling stock. For the purpose of the meeting Sir Henry Fowler, Deputy Chief Mechanical Engineer of the London, Midland and Scottish Railway, gave a summary of these reports. That for the British Empire was prepared by Sir Henry Fowler himself. Although the majority of administrations used steel castings for locomotive axle-boxes, some of the more modern examples showed a reversion to the solid type, made of non-ferrous alloys for coupled wheels. The tender and bogie boxes being usually of cast-iron or cast-steel with a separate brass. Dust shields were usually fitted to tender boxes, but their adoption for locomotive boxes did not seem to be the general practice. The angle included at the centre of the journal by the arc of contact varied considerably for each class of axle-box. For coupled wheel axle-boxes the figures ranged from 120 to 180 deg., and for bogie and truck wheels from 60 deg. for the Southern Railway (Great Britain) to 180 deg. for the Great Western Railway (Great Britain). There existed considerable difference of opinion regarding the pressure allowable on the journal. For engine axle-boxes the figure varied from 112 lb. to 410 lb. per square inch and for tender boxes it was usually over 300 lb. per square inch. The considerable divergence in the allowable reduction in the diameter of the journal for wear showed that the range which would give satisfactory results was very wide. The white metals (anti-friction alloys) used varied greatly in composition, and could be divided into four categories namely those containing: (1) high tin, (2) medium tin, (3) high lead, and (4) medium lead: all were stated to give satisfactory results under the conditions obtaining. The best position for oil grooves in bearings and white metal pockets did not seem to be at all definite, and there was little or no uniformity of opinion upon the subject. For coupled axle-boxes the top feed method of lubrication was almost universal in conjunction with underfeed oil pads whilst tender and bogie boxes were usually of the underfeed type. Although still in the experimental stage on many railways, there seemed to be a growing tendency to employ mechanical methods of lubrication which gave a constant and uniform feed and enabled the oil consumption to be reduced. None of the administrations reporting had fitted or experimented with roller or ball bearings on locomotive axle-boxes. In the matter of lubricants for locomotives there existed great diversity in composition. The general practice was to use a mineral oil or a mixture in which at least 75 per cent. was mineral oil.

Coaching stock axle-boxes were universally of the outside bearing type and were usually provided with open fronts. In the United Kingdom cast-iron boxes were generally used, but other administrations usually employed cast steel for new stock. The angle included at the centre of the journal by the arc of contact was smaller than for locomotive bearings whilst the pressure on the journal was high. With regard to antifriction alloys used for coaching stock axle-boxes, the same variations existed as was the case with white metals utilised for locomotive axle-boxes. The underfeed method for the lubrication of coaching stock was universal. While some few administrations used spring-frame oil pads the majority packed the underkeep with wool or cotton waste. The oil most generally used was a straight mineral oil, and only in countries in which extremes of temperature occurred was there any variation between the quality used in summer and that used in winter. The consumption of oil varied considerably; only a few administrations collected and refined the waste oil taken from axle-boxes. With regard to the use of roller or ball-bearings little information had been forthcoming. The London Midland and Scottish Railway, which had made systematic tests using suburban passenger stock, had found that, whilst there was a variation in resistance in favour of the roller bearing when starting, this disappeared after running a short time. Moreover no saving had been obtained in coal consumption per ton-mile by the adoption of roller bearings. The lubricant used in the trials was mineral oil. The cost of fitting roller bearings amounted to 22*l.*, whereas the cost of plain bearings was only 4*l.* No trouble had been experienced with these roller bearings, and so far as end-wear was concerned, they had so far proved to be efficient.

As in the case of coaching stock the open-fronted type of axle-box was the one most widely used for wagons, dust shields being fitted in most cases. The journal pressures were usually high, being in some cases over 700 lb. per square inch. Great divergence existed in the allowance of wear of the journals before scrapping. The white antifriction alloys used for wagons varied considerably in composition. The underfeed method for the lubrication of wagons was that most in vogue in conjunction with wool or cotton waste packing or with spring oil pads. Although the composition of the lubricant varied, straight mineral oil was now most generally used. No experiments had had been made with roller or ball bearings for wagon stock.

The report on lubrication for America was prepared by Mr. George H. Emerson, Chief of Motive Power and Equipment, Baltimore and Ohio Railroad. Detailed drawings of the various axle-boxes used by American railways for locomotive leading truck driving, trailing, and tender wheels, were supplied. In the matter of dust guards, no shields could be used for locomotive wheels, but the general American practice was to use wood guards for tender and other rolling-stock boxes. The angle included at the centre of the journal by the arc of contact gave a general average of 129 deg. 55 min. for locomotive leading truck wheels, 172 deg. 16 min. for driving wheels and 129 deg. 6 min. for trailing wheels. The figure for locomotive tenders, passenger and freight-car trucks varied considerably, and the average was 108 deg. 3 min. Considerable divergence of opinion existed about the pressure allowable on the journal. In the case of locomotive axle-boxes, the values given varied from 104 lb. to 298 lb. per square inch. The general average figure for locomotive tenders was 400 lb. per square inch, for passenger coaches from 300 lb. to 400 lb., and for freight cars from 450 lb. to 500 lb. per square inch. All these figures related to the projected area.

The question of the limits of wear for axles and bearings had been standardised as far as possible by the Inter-State Commerce Commission. The composition of the white metal used as a lining for journal bearings varied considerably, but, generally speaking, the alloy used was of the high-lead type. Some difference of opinion existed as to the position, shape and depth of the oil grooves in the bearing. In the case of leading trucks, it was general practice to have two to three oil holes in the tops of bearings, and a centre oil groove on the face of the bearing from $\frac{1}{2}$ in. to $1\frac{1}{4}$ in. wide and from $\frac{3}{8}$ in. to $\frac{3}{4}$ in. deep. It was customary to use two grease grooves in driving wheel crown bearings, one on each side of the centre and connected at the ends by cross grooves $\frac{3}{4}$ in. wide and $\frac{3}{8}$ in. deep. Outside oil channels were generally used for trailing truck bearings, and were situated on the top of the bearing in the centre, with from one to three oil holes leading to the centre groove on the inside face of the bearing. No oil grooves were used in connection with tender and car truck journal bearings.

The method of lubrication generally adopted for locomotive axle-boxes was the top-feed, although some administrations used grease only for driving wheel boxes, necessitating special arrangements. Packing for underfeed lubrication consisted of wool or cotton waste mixed in varying proportions. Experiments had been made with roller bearings, but the data available were not sufficient to justify serious consideration of their adoption generally. On motor-cars used on branch lines roller bearings were used quite extensively. For heavier cars, considerable trouble had been experienced with the rollers breaking in service. The first cost of application of these bearings was very high, and heavy lubricating expenses incurred with them had also to be taken into account.

Plain bearings with an underfeed of oil were used almost exclusively for passenger and freight cars and locomotive tenders. Mechanical lubrication for locomotives had been tried by several railways with varying results. The general practice was to use a straight mineral oil as lubricant. In some cases a lead soap base or a small percentage of rape oil was added. Slight summer and winter variations in composition had been reported by several railways. Well-thought-out schemes had been devised for the reclamation of packing. Two systems were used, the "hot oil" and the centrifugal. In the former process, the packing was first placed in a vat containing steam-heated coils, the oil oozed out of the packing, and was drained away. The waste was then placed on a netting picking-table and shaken to knock out dirt. Passing on to the double-washing vat, it was stirred in hot oil and pressed. This operation having been repeated several times the reclaimed packing was ready for mixing with new waste and resaturating with clean oil. The use of a centrifugal machine facilitated the extraction of oil from packing, and also permitted the rapid filtration of the reclaimed oil itself.

The report on the question of the lubrication of axle-boxes for all other countries except the British Empire and America was prepared by M. J. Tete, of the Paris, Lyons and Mediterranean Railway. The use of cast steel for the body of the axle-box was extending more and more and this appeared to be the only suitable material for the coaching and wagon stock of large railways in view of the heavy loads carried and of the violent shocks often experienced during shunting operations. For new stock it was desirable to adopt boxes made in one piece, open-fronted, with a removable glut, and with the front cover held in position by four or five bolts provided with lock nuts. The design of the box should be such that the interior was easily accessible for inspection purposes. For boxes made in one piece in which the outer cover pivoted about an axis, the replenishing of oil was accomplished by opening the cover. For other types of boxes, this was generally done through filling holes, and the use of oil cups greatly expedited matters.

The use of dust shields was becoming very general. These were placed in a recess provided at the back of the box, and were intended to close the space between the axle and the edges of the opening. Dust shields served the double purpose of preventing water or dust from entering, and oil from being splashed out of the axle-box. The thickness of the shields varied from $\frac{1}{16}$ in. to $\frac{7}{8}$ in., and some were made in one, and some in two pieces. The materials used consisted chiefly of wood, felt stiffened with sheet metal or leather, and oil-cloth. In one case the dust shield took the form of a disc of malleable cast-iron which curved inwards and was fitted on the axle. Oil was supplied from the bottom of the box to the journal by means of either wool or cotton waste packing or a spring oil pad.

Three types of mechanical lubrication method were at the present time under trial by various administrations. One, known as the "Isothermal" box, was being tried by three French railways—Est, Midi, and Nord. This arrangement consisted of a plate screwed to the outer face of the axle, concentric with the journal. This plate curved over the outer collar of the journal in such a way that the two extremities which, when running dipped into the oil in the box, were approximately over the outer fillet of the journal. These picked up the oil as they rotated and led it to grooves cut in the upper

face of the brass, from which it passed to oil grooves which distributed it along the journal. When the speed was high, the oil was projected by centrifugal force against the walls of the axle-box, and channels cast in the upper portion of the box lead the oil to the upper face of the brass. The Dutch State Railways were testing a system of mechanical lubrication in which the oil was led to the journal by means of a chain driven by some small discs pressed against the bottom of the journal by a helical spring. Another system which had given satisfactory results with highly fluid lubricating oils had been used by the Andalusian Railways. This consisted of an oiling ring driven by a ball, rolling on the journal in a spherical cavity in the middle of the brass. Mechanical lubrication by means of pumps was in the experimental stage.

When oil grooves were cut in the bearing surface of brasses for use in connection with top-feed lubrication, it was important that they should not form a sharp edge on the bearing surface or the oil might be scraped off the journal. The correct polishing of the journal was a matter of absolute necessity and was best done by mechanical means, either by using hardened steel roller burnishers or abrasives. The angle made by the arc of contact in the case of the coaching stock and wagons of the reporting railways ranged from 90 deg. to 120 deg. The pressure allowable on the journal in pounds per square inch varied enormously, figures as low as 300 lb. and as high as 900 lb. being quoted. For locomotive journals the values were 120 deg. to 180 deg. and 200 lb. to 400 lb. per square inch, respectively.

All the locomotive and tender boxes of the reporting administrations appeared to have the under-feed method of lubrication. Top-feed lubrication was also employed for locomotive axle-boxes; the Paris–Lyons–Mediterranean Railway had, however, completely abandoned it for all locomotives constructed to their drawings during the last twenty years, and had found no resultant disadvantages. Mineral oils produced by the distillation of crude petroleum were at the present time universally used for axle-box lubrication. In a few cases a certain proportion of other oils were added in order to increase their fluidity or to improve their lubricating properties. The consumption of oil was, in general, closely supervised. Lubricants for locomotives and tenders were, as a rule, issued in accordance with an allowance based on mileage. Used oils were recovered by some administrations and were again employed for the lubrication of wagon boxes.

The application of roller, disc, or ball bearings by the Swedish State Railways to the axle-boxes of a large number of vehicles, formed an innovation of very great interest. This administration had had experience extending over several years with axle-boxes of this description. Bogie coaches to the number of 227 and 50 six-wheel wagons had been provided with disc, roller, or ball bearing boxes and all new coaching stock was to be equipped in similar fashion. Economy in fuel consumption had apparently been gained by the adoption of ball bearings and the starting of trains was rendered easier. Lubrication was carried out under conditions similar to those which obtained for plain bearing boxes. Maintenance costs, depreciation values, and other vital matters were not, however, fully known, and even approximate figures were not available. It was therefore necessary, before giving a definite opinion on these types of axle-boxes, to wait until experience had furnished more complete information on the subject.

M. G. Forte of the Italian State Railways, stated that a great deal of the oil consumption was due to the frequent examination of boxes. As a result of experiments, their boxes were now packed with a mixture of half wool and half hair, and the boxes were then sealed. Once a month these boxes were examined and re-oiled by the shed staff. Results in one district with this system had proved very satisfactory.

Mr. R. E. L. Maunsell, of the Southern Railway, pointed out that the question of the dissipation of heat from axle boxes had not received sufficient attention. He had conducted tests which showed that if the top of the box was machined, so as to give proper contact between the brass sheet and the box, then the temperature of the bearing was 30 deg. lower than in a box the top of which was not machined. M. Lancreron, of the Nord, reported good results obtained with the "Isothermal" system. This equipment was used on the tenders of express locomotives as well as on the carriages. The boxes had been examined monthly, and 100 grammes of oil added. The goods wagons so fitted had not been in service sufficiently long to obtain definite results. The Paris-Brussels stock was fitted with them, and the only cases of heating had been found to be due to some trivial mechanical defect. M. Poncet then pointed out that the Isothermal Company were constructing a bogie box with dust shields at both ends for Pacific locomotives of the Est. The President asked if the resistance of these boxes was greater or less than others, and M. Lancreron replied that although no tests had been made, he thought it was less.

M. Lacoin, in referring to the question of ball or roller bearings, said he had tested a suburban train with half the stock using roller bearings and the other half simple brass ones. The economy obtained with the roller bearings was 8 per cent. at speeds of 50 km. per hour. Their cost was high, and they were found to be of no great value except possibly for refrigerator and other special vans in fast goods service. M. Ahlberg, Sweden, agreed that roller bearings were expensive, and the journal being subject to hammering at the rail joints, further investigation was necessary before they could be widely used. Mr. R. W. Reid, of the L.M. and S. Railway, stated that tests with roller bearings on passenger trains had shown little advantage except possibly at starting. He was not in agreement with the suggestion that it was necessary to machine the top of an axle-box. The grinding of journals had given better running and lower temperatures. He had got good results with a lead base white metal on heavy loads.

Mr. H. N. Gresley indicated that the chief trouble in locomotive bearings was in the coupled axle-boxes. He was using mechanical lubricators quite successfully, the only difficulty being the flexible connection to the top of the box. Shunting engines showed considerable saving in oil owing to the time that they were standing. He sought information from the American delegates on the use of grease for locomotive boxes. It was not, in his opinion, necessary to machine the top of the axle-boxes. In metalling bearings the principal point to watch was the careful tinning of the brass. Mr. J. T. Wallis, of the Pennsylvania Railroad, said that 98 per cent. of American locomotives had grease lubrication.

On Wednesday morning, June 24, the attempt was made to frame a first report on the subject of the Reduction of the Cost of Traction. Firstly, Question IVA, relating to fuel was dealt with. In the proposed report it was stated that the choice of fuel depended upon the supplies that were available. The coal should be selected which gave the best results in burning. When it was difficult to obtain supplies of the same quality at all times, it was advisable to resort to the process of blending by mixing. For this purpose mechanical devices at the pits or at points along the railroad were necessary. The statistics kept by the various railways did not admit of comparison as the methods in use varied considerably. Standardisation of methods would prove of great service. When this point was reached in considering the report there was a great amount of discussion on the suitability of the virtual ton-kilometre method of dealing with results.

Fuel oil, when its price allowed its use, had many advantages such as the reduction of consumption when standing, the increase in power when running, the greater ease in handling, and the little smoke produced when burning. Pulverised and colloidal fuels had only been used experimentally so far. As far as mechanical stokers were concerned their use permitted the handling of greater quantities of fuel than was otherwise possible, and they could be justified for large coal consumptions. Their economy was not yet determined. The utility of smoke-consuming devices was not yet settled. Various other conclusions were left over for further consideration in later sessions.

(To be continued.)

THE NATIONAL PHYSICAL LABORATORY.

THE annual inspection of the National Physical Laboratory by the General Board, on Tuesday last, was initiated by the ceremonial opening of the new entrance to the grounds. With the construction of the new Kelvin and Rayleigh avenues, and the erection of iron gates at the Queen's-road entrance, the last trace of the rural character of the approach to Bushy House has gone. The new avenues lead over to the nearly-completed buildings of the High-Voltage Laboratory and the Chemical Laboratory, in the north-west corner of the grounds. The visitors—more than a thousand had accepted invitations—were received by Sir Charles Sherrington, as President of the Royal Society *ex officio* Chairman of the Board, Sir Arthur Schuster, Chairman of the Executive Committee, and Sir Joseph E. Petavel, Director of the Laboratory. Nearly two hundred special demonstrations had been arranged, and everything was explained by the members of the staff with the usual marked courtesy. There have been few changes in the staff during the year 1924, but the Board had to record the deaths of Sir George Beilby, member of the Executive since 1899, and of Sir Maurice Fitzmaurice. The steady growth of the work has been so well maintained, that we must abbreviate our comments on the activities of the various departments.*

Engineering Department: Lubrication; Friction.—The continued experiments on boundary lubrication show that little is gained by adding compounds of the alcohol type, like octyl and cetyl alcohol, to Bayonne oil, whilst the addition of 1 per cent. of stearic acid to this oil reduced its coefficient of friction to that of castor oil; this is a remarkable result, even for a fatty acid. In the tests of a special bearing metal, made of bronze and graphite, which was supposed not to need lubrication for some time after an initial impregnation with oil, the bearing (inside diameter 1 in., outside diameter 1·5 in.) was soaked for 12 hours in castor oil and then fitted to Dr. Stanton's pendulum bearing housing for rocking tests, the 250-lb. pendulum being swung continuously for 45 hours during the day time. The rate of damping per oscillation was found gradually to increase from 0·125 deg. to 0·260 deg. during the first two days and then remained fairly constant.

The same apparatus was used for determining the friction of the pistons and piston rings of internal-combustion engines. Two cast-iron cylinders, spares of a 70-h.p. Renault air-cooled engine, were bolted together co-axially end to end, the common head forming an air-tight joint; the two pistons of the two halves of the coupled cylinders were rigidly connected together and to the rocking link of the pendulum. An electric heater was fitted into the common head, and the cylinder-wall temperature was determined by the aid of a thermocouple; the air pressure behind the pistons was varied from zero to 80 lb. per square inch. The variations in the friction observed with different air pressures suggested that air was leaking through gaps in the piston rings to the space behind them, thus setting up a radial pressure of the rings against the wall, in addition to the radial elastic pressure of the rings. A series of small holes was therefore drilled through the metal (mild steel) of the piston at the bottom of the ring recesses, and the holes were fitted with plugs for the attachment of strong rubber piping joined to a Bourdon gauge. The suspected air leakage was in this way fully established and shown to be greatest in the first (inner) piston ring and smallest and insignificant in the third (outer) ring; the practice of using not more than three rings was thus justified. The experiments prove that the lubrication of piston rings (castor oil was used) is of

* The National Physical Laboratory. Report for the Year 1924. Published by H.M. Stationery Office for the Department of Scientific and Industrial Research. Price 8s. 6d. net.

the boundary type and depends upon the normal pressure between the rings and cylinder. These results were not much affected by the temperature of the cylinder walls (up to 100 deg. C.); with ringless pistons the oil temperature was more important, and with small pressure and a high viscosity, oil-film lubrication of the Reynolds type was obtained.

The further tests of heavy oils again demonstrated that materials tend to improve in quality when it is known that they will be subjected to tests. In the year 1921 the highest seizing temperature of some oils submitted was 170 deg. C. at 1,000 lb. per square inch; in the following two years some motor cylinder oils and some special oils only seized at 213 deg. and 234 deg. while in the repeat tests of 1924 of the same three series no seizure was observed up to 250 deg. Seizure actually occurred at 256 deg. under a load of 1,500 lb. per square inch. The coefficient of friction, ranging from 0·0010 to 0·0014 at its minimum value between 100 deg. and 130 deg. C., was lower than with a ball or other bearing—which, of corresponding size, however, would still have the advantage of lower starting friction. In these experiments the journal was kept flooded with oil. As regards friction between dry and graphited metal surfaces at high temperatures, Mr. Jakeman had found that the limiting temperature of about 350 deg. or 360 deg. C. (660 deg. to 680 deg. F.), at which seizure took place, seemed to be independent of the metal and of the presence of graphite. Whatever the metal, friction went up to three or four times its value at that temperature. It was not a time effect, but might be a gas effect; that is, the lubrication might be due to the gas film. If that were the case reduction of the gas pressure should decrease the friction; but the temperature of seizure was raised more and more as the air pressure was reduced to 0·5 and 0·2 atmosphere, and the addition of carbon dioxide or coal gas had the same effect as the reduction of air pressure. This latter observation suggests chemical influence, and the problem is being investigated further with different gases and different metals, glass, &c.

As regards the variation of fluid friction with distance from the leading edge of a thin flat plate tangential to the air current, the experiments made confirm the theory of Kármán that the boundary film, forming at the leading edge, gradually increases in thickness down stream and eventually becomes turbulent, so that the formula of Blasius only holds for certain distances.

The work for the Laminated Spring Research Committee comprises road tests on an Army lorry (30 cwt.) and on a 16-h.p. touring car run on various tracks at various speeds, and endurance tests. In the former tests, the spring deflections are recorded on a paper roll (independently driven at a constant speed) by means of a piano wire encased in a flexible steel tube; the simultaneous records concern front and rear springs and also the master plates and short plates of a spring. The endurance tests were first limited to three laminated springs of ten leaves, having no nip, moderate nip, or excessive nip but otherwise identical. They all stood 1,000,000 oscillations with load ranges from 224 lb. to 560 lb.; when the range was varied between 56 lb. and 728 lb., however, a leaf failed in each spring at 900,000, 482,000 and 277,000 repetitions, respectively, showing a marked decrease of endurance with increased nip. The friction and the average work lost per repetition were determined, and experiments with improved spring designs are in hand.

Testing of Materials.—The tests under this heading also comprise these and other steel springs of nickel steel. As regards creep it is found that the limiting creep stress (the load per unit of original area which will just not break a bar when maintained for a very long time) of Armco iron closely approaches the ultimate tensile stress at 180 deg. C., but falls off rapidly at higher temperatures, becoming half that value at 350 deg. C.; moreover it is not definitely related to the alternating stress in fatigue. At high temperatures, up to 80 deg. C., the nickel-chromium alloys prove superior to iron as regards creep. These alloys, hardened and tempered, should also be used in preference to carbon steel for important parts of aeroplanes exposed to low temperatures; they were tested down to —80 deg. C. The notched bar impact tests gave, at 0 deg., about twice the value obtained at —40 deg., whilst the microstructure and Brinell test did not indicate any difference. With respect to the co-ordination of fatigue tests, comparative investigation of solid and hollow specimens of two steels (0·13 and 0·33 per cent. of carbon), conducted by Messrs. H. F. Gough and H. J. Tapsell on Haigh (reversed direct stress), Wöhler (reversed bending stress) and Stromeyer (reversed torsional stress) machines, showed that the Wöhler endurance limit was largely independent of the type of working or of the specimen. All the Wöhler ranges were greater than with direct stress cycles, and hollow specimens gave lower Wöhler, and particularly lower torsional, ranges than solid specimens. Those results are of considerable theoretical and practical interest. It should be recognized that one of the principal reasons for the discrepancies between the limits observed on different machines is the extra-elastic state of the material which it exhibits when subjected to cycles of safe ranges of strain. The Haigh machine applies cycles of specific loading or stress while the Wöhler and Stromeyer specimens are subjected to cycles of specific stress, although in the last case increased strain results in increased applied torque. Hence the fatigue failures of hollow specimens in Haigh and Stromeyer tests are more consistent with Haigh's constant-strain-energy theorem than with Guest's assumption of maximum shear stress.

Particular interest attaches to the investigations in the Engineering, Metallurgical and Radiology departments, of single crystals of aluminium, subjected to repetition of direct stress (at 2,000 cycles per minute), torsional stress (200 to 1,000 cycles per minute), slow cycles of tensile loading (by hand) and tensile impact. Deformation occurred under all these stresses by a process of shear on certain crystallographic octahedral planes, and the direction of shear in the plane coincided with that of the principal lines of atoms. Phenomena, such as elastic hysteresis, creep under load, etc., hitherto associated with the presence of non-crystalline material in metallic aggregates, were also exhibited by specimens consisting initially of a single crystal. These single crystals gave way in fatigue as they did in G. I. Taylor's static tests.

The standard sockets of cast-iron water pipes having been considered unnecessarily thick and heavy, Mr. R. G. C. Batson has determined the stresses arising in the sockets owing to the lead caulking and to internal water pressure up to 325 lb. per sq. in. Two pipes of 25 in. diameter were taken; the socket of the one was made to the B.E.S.A. standard; the other was much lighter. By mirror and telescope measurements of the external diameter, extending over three weeks, it has been ascertained that the socket first expands on caulking with lead and under water pressures (of 325 lb. per sq. in.) and then contracts very slowly, some lead flowing out; readings to 0·00001 in., taken on several diameters, were found to fluctuate considerably.

(To be continued.)

BELGIAN TRAMWAY EXTENSIONS.—The Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, announces that the Société des Tramways Electriques du Pays de Charleroi, whose head offices are at 91, rue de l'Enseignement, Brussels, is about to make the following extensions to its electric tramway lines in the Charleroi district: The Montigny-sur-Sambre–Charleroi line is to be prolonged to La Neuville; the Charleroi–Couillet line is to be extended to Chatelet, and the Charleroi–Gilly line is to be prolonged to Vieux-Campinaire.

PERSONAL.—Messrs. Alfred Herbert, Limited, of Coventry, the agents for all Morse products, such as drills, reamers, sockets, &c., are, in addition, sole agents for all Morse screwing tackle.—Messrs. Escher, Wyss and Co., of Zürich, have opened an office at 74, Bath-street, Glasgow, C. 2.—Messrs. Wollaston Gas Producers (Manchester), Limited, have removed their offices to Bank of England Chambers, Tib-lane, Cross-street, Manchester. The future address of Mr. T. Roland Wollaston, consulting engineer, is also that given above.

THE KANGO ELECTRO-MECHANICAL HAMMER.

AN electrically-operated percussion hammer, which has been introduced recently by the Kango Company, Limited, of 78, Petty France, S.W.1, under the name of the Kango Hammer, is of particular interest in that it operates on a principle which does not appear to have had previous application for practical commercial purposes. This principle can be best understood by considering the motion of a rod, free to move in guides, to which an out-of-balance wheel is attached, the rod being limited in its travel at one end by a stop, and at the other by a spring. When the wheel is rotated, the inertia forces set up will cause the rod to oscillate, and a series of blows will be struck against the stop. The spring will have the effect of increasing the energy in each blow.

In applying this principle to the Kango hammer, a small series-wound electric motor is employed for driving the out-of-balance wheels. To eliminate inertia forces at right angles to the line of motion, two wheels are employed which rotate in opposite directions. In general appearance the hammer resembles one of the pneumatic type, a stirrup-shaped handle being fitted at the upper end, through which the cable is led and on which the trigger switch is mounted. The motor is contained within the circular casing below the handle and drives a spline shaft through a sliding and flexible coupling. This spline shaft drives the striking element, which is housed in the lower part of the casing, through a bevel pinion engaging with two crown wheels. All three wheels are carried on the striking element and therefore reciprocate with it. The crown wheels are mounted on pins projecting from the sides of the striker, and, as mentioned, rotate in opposite directions. A heavy semi-circular weight is formed on one side of each wheel, and the teeth are so engaged with those of the pinion that the weights are opposite to each other when they are at either the top or bottom of their revolution. The lower end of the striking element forms the hammer head, and the blow is conveyed to the tool through a transmitter, which is secured to the lower end of the casing by a flexible leather diaphragm. The whole of the striking elements work in an oil bath, and the oil is retained by the diaphragm at the lower, and by felt-ring washers at the upper end. The spiral spring which absorbs the energy on the inward stroke is mounted behind the striking element, and tends to hold the hammer head against the transmitter. The whole of the mechanism can be removed for inspection by unscrewing a large threaded collar at the centre of the casing, while the motor can be inspected and removed by taking off the handle.

An interesting feature of the mechanism is that, above a certain speed of rotation, the combination of the force due to the spring with the vertical inertia force due to the weights, results in a motion of half the frequency of rotation, the energy in each blow being doubled. In the hammer at present on the market, the speed is kept below this critical value, but it is proposed to utilise the effect in a larger hammer which will be introduced at a later date. The hammer can be supplied for various voltages, either Alternating or Continuous, and has a very low consumption, amounting to about 1·3 ampere on a 220-volt circuit.

HEAT TREATMENT OF STEEL.—A comprehensive little booklet issued by Messrs. G. P. Wall, Magneto Steel and Wire Works, Penistone Road, Sheffield, contains many useful hints on the heat treatment of all grades of steel. The notes on the annealing, normalising and hardening of high-speed steel, and also those on case hardening and the heat treatment of case-carburised material, are specially good. A section dealing with the treatment of magnet steel used in the manufacture of permanent magnets is included, and the book closes with a few useful tables. Copies of the booklet may be obtained upon application to the firm at the above address.

QUARRY ACCIDENTS IN THE UNITED STATES.—The Bureau of Mines of the U.S. Department of the Interior has recently issued Bulletin 246, by Mr. W. W. Adams, dealing with accidents in limestone, cement rock, granite, trap rock, marble, sandstone and bluestone, and slate quarries, during the year 1923. The bulletin states that more men were employed in stone quarries in 1923 than in any year since 1915, and, whereas the average number of work days per man was the highest ever reported, the fatality rate from accidents was the lowest on record. The non-fatal injury rate was, however, slightly higher than that for recent years. During 1923, the number of employees totalled 92,455, and 25,545,859 shifts were worked, representing an average of 276 work days per man. Accidents were responsible for the death of 143 men and the injury of 14,990, indicating a fatality rate of 1·68 and an injury rate of 176 per thousand full-time workers. The corresponding rates for 1922 were 1·92 and 172, respectively. For the five-year period 1916-1920, the rates were 2·10 killed and 160 injured. The principal causes of fatal accidents in the quarries were falls or slides of rock or overburden, haulage gears, explosives, and falls of individuals.

LABOUR NOTES.

REPRESENTATIVES of the executive councils of the engineering trade unions met in London on June 19 to consider the further letter which had been received from the Engineering and Allied Employers National Federation. In the course of that communication, it will be recalled, the employers said :—

"It would appear that the proposal of the employers of April 22 has been looked upon not as a proposal for acceptance by employers and workpeople as a mutual effort to revivify the industry and create employment, but as a reply to an application for advance in wages unconditionally. If so, an unfortunate mistake has been made. Any advance in wages without compensating conditions is impracticable. The employers have asked the unions to join with them in their endeavour to restore the industry. They have proposed a joint approach to the Government on the question of international hours of labour, they have undertaken to review the situation when competitor nations effectively bring their hours into close relations with those in this country, and they have asked the unions to consider the proposal with due regard to the vital necessities of the industry. The employers are unable to bring themselves to the conclusion that the circumstances of the case and the necessities of the industry can be met by a resolution of such a general and negative character as that adopted by the union representatives on May 20. . . . The situation has, since we last met you, become more serious, and the industrial position is one of extreme gravity. My Board feel that the unions having a direct interest in maintaining and furthering the interests of the workpeople must be asked to apply their minds with much greater precision to the situation. It is to be hoped that the gravity of the situation will convince your representatives of the necessity of going much more deeply into the position than is apparent from the resolution of May 20."

The letter concluded by stating that the offer of a further conference was still open. After considering the matter for just over two hours, the conference of executive representatives adopted the following resolution :—"This conference, after considering the employers' letter of June 2, while adhering to its previous policy, agrees to meet the employers, with a view to hearing explanations of the letter referred to." It is to be hoped that Mr. Brownlie and his colleagues will make better use of this opportunity to adjust matters on a reasonable basis than they did of the last one.

The trouble in the coal-mining industry seems now to be approaching a highly critical stage. On Tuesday, the Sub-Committee of coalowners' and miners' representatives which was appointed to investigate the industry's economic state, concluded its labours. The following official report was issued at the close of the meeting :—

"At a meeting of the Joint Sub-Committee of representatives of the Mining Association and the Miners' Federation, the owners gave their view of the remedies which should be applied to deal with the position of the coal industry. In their view, the main cause of the difficulties was the increased cost of production, due mainly to the shorter working day, and to the terms of the present agreement. The position was so serious that they (the owners) would be compelled to give one month's notice on June 30 of the termination of the existing agreement. The owners suggested that it was in the interests of the workmen as well as of the owners that there should be a reversion to the eight hours day and that the Government should accordingly be requested to pass the necessary legislation. The workmen's representatives replied that they would not consider the question of longer hours, as they held that that was no solution for the problem facing the industry. The owners intimated that they were not in a position to-day to put forward details of their proposals for a new agreement, but it would be for the two sides to meet as early as possible for this purpose. They intimated that they would communicate with the workmen's side as to a further meeting after the meeting of the Central Committee of the Mining Association on Thursday.

The miners' representatives on the sub-committee reported to the full executive of the Miners' Federation on Wednesday. As the inquiry is now concluded and notice has been given to terminate the existing agreement, the negotiation of a new agreement will be proceeded with as soon as possible. A national conference of miners' delegates is to be held in London on July 3 for the purpose of instructing the executive on the lines to be followed in the negotiations.

The Ministry of Labour states that on June 15, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,280,700, made up of 1,011,500 men, 34,700 boys, 207,600 women, and 26,900 girls.

According to the *Ministry of Labour Gazette*, employment showed little change, on the whole, during May. There was an improvement in the clothing and furnishing trades, but a further marked decline in the coal-mining industry. Among the 11,500,000 workpeople insured against unemployment under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed at May 25, 1925, was 11·2, as compared with 11·2 at April 27, 1925, and with 9·5 at May 26, 1924. Among the members of those trade unions from which returns were received the percentage unemployed was 10·1 at the end of May, 1925, compared with 9·4 at the end of April, 1925, and with 7 at the end of May, 1924. Employment was good, on the whole, with coach-builders, upholsterers and brickmakers, with skilled operatives in the building trades, and in the tailoring and dressmaking trades; it was fairly good with cotton weavers, mill-sawyers, brushmakers, in the furnishing, silk and carpet trades, and in some sections of the printing and metal trades. In the wool textile industry, in coal mining, in the iron and steel industry, in tin plate and steel-sheet manufacture, in the marine and heavy engineering trades, and in the shipbuilding industry, employment continued bad.

In the industries for which statistics are regularly compiled by the Ministry of Labour the changes in rates of wages reported in May resulted in an aggregate reduction of 16,400*l.* in the weekly full-time wages of over 500,000 workpeople, and in an aggregate increase of 3,350*l.* in the weekly wages of 36,000 workpeople. The principal groups of workpeople whose wages were reduced were coal miners in Yorkshire and the East Midlands, where there was a slight decrease in the percentage addition to basis rates (amounting to 0·3 per cent. on current rates); and steel smelters and millmen in various districts in England and Scotland, whose wages were reduced by about 1 per cent. on current rates. Other important groups of workpeople whose wages were reduced included iron-ore miners in Cumberland, blastfurnacemen in Cumberland and Scotland, Siemens steel workers in South-West Wales, tinplate makers in South Wales and Monmouthshire, electrical cable makers, hosiery workers at Hawick, coopers, furniture trade operatives in London, road transport workers in Scotland, leather belt and roller leather makers, and workpeople employed in the non-trading services of most of the local authorities in London. Among the workpeople who received increases in rates of wages were heating and domestic engineers, coal miners in the Radstock district, the lower-paid men in ironstone mines in Cleveland, and blastfurnacemen in Lincolnshire. There were also increases in the minimum rates fixed under the Trade Boards Acts for most classes of workpeople employed in the brush and broom trade.

During the first five months of 1925, the changes reported to the Ministry of Labour, in the industries for which statistics are compiled, have resulted in net increases amounting to 70,000*l.* in the weekly full-time wages of over 700,000 workpeople and in net reductions of nearly 40,000*l.* in those of nearly 690,000 workpeople. In the corresponding period of 1924 there were net increases of about 480,000*l.* in the weekly full-time wages of 2,480,000 workpeople and net reductions of 13,500*l.* in the weekly wages of nearly 250,000 workpeople.

The number of trade disputes involving stoppages of work reported to the Ministry of Labour as beginning in May was 47. In addition, 34 disputes which began before May were still in progress at the beginning of the month. The number of workpeople involved in all disputes in May (including workpeople thrown out of work at the establishments where the disputes occurred, but not themselves parties to the disputes) was about 27,000; the estimated aggregate duration of all disputes during May was about 202,000 working days. These figures compare with totals of approximately 25,000 workpeople involved and 122,000 days lost in the previous month. The aggregate duration of all disputes in progress in the first five months of 1925 was about 658,000 working days, and the total number of workpeople involved in these disputes was 102,000. The figures for the corresponding period of 1924 were 2,963,000 days and 356,000 workpeople respectively.

Reporting on the conference held on June 4 on the invitation of the Miners' Federation of Great Britain, Mr. A. A. H. Findlay, general secretary of the United Patternmakers' Association, says that it was plainly evident from the speeches made that the movement was a very, very long way from getting unity for a strike policy. He gathered the impression, he tells members, that it would take this year to clear up the difficulties existing between the various unions and their constitutional barriers to a joint control, and without such the possibilities of success are, in Mr. Findlay's opinion, very small indeed.

The General Federation of Trade Unions has issued a manifesto in which it states that it views with interest and pleasure the recent pronouncements in favour of trade union amalgamations or combinations for defensive purposes, and reminds those interested in the cause that, over twenty-five years ago, it was specifically established for this avowed purpose by the trade union movement acting through the Trades Union Congress. The Federation offers, it is pointed out, inexpensive machinery for the defence of industrial workers and the conduct of unavoidable disputes. It has never failed its affiliated societies, either by help or guidance in negotiations, legal advice, accountancy, technical information, &c., or the payment of Federation benefit in case of actual dispute, whether of one man or 100,000. It has received from the affiliated unions 1,286,608*l.* It has paid in dispute benefits no less than 1,138,793*l.* 9*s.* 5*d.*, and it has a cash balance exceeding 150,000*l.*, so that every penny of contributions has gone back to its members, or is held in reserve. This financial result affords, it is claimed, convincing proof of the carefulness with which its affairs are administered. "It is democratically governed," the manifesto declares, "and its rules are democratically revised each year, and it hereby fearlessly declares that the trade union movement would be well advised to avoid the creation of rival or overlapping organisations, and concentrate upon the strengthening of the General Federation of Trade Unions, which already represents 118 *bona fide* trade unions."

The objects of the General Federation of Trade Unions are, it may be recalled, "to uphold the rights of combination of Labour, to improve in every direction the general position and status of the workers by the inauguration of a policy that shall secure to them the power to determine the economic and social condition under which they shall work and live, and to secure unity of action amongst all societies forming the Federation, and to assist affiliated unions to perfect their organisations; to promote industrial peace, and by all amicable means such as conciliation, mediation, references, or by the establishment of permanent boards, to prevent strikes or lock-outs between employers and workmen, or disputes between trades or organisations; where differences do occur, to assist in their settlement by just and equitable methods; to establish a fund for mutual assistance and support and for carrying out the foregoing objects." The objects of the organisation desired by Mr. Cook and his associates are, of course, vastly different.

In the 26th annual report of the General Federation of Trade Unions, Mr. Appleton states that the number of Societies affiliated to the organisation is 118, with an aggregate membership of 830,316. In 1924, the membership was 920,050; in 1923 it was 1,056,131; in 1922, 1,371,634; and in 1921, 1,583,058. It is now, in fact, lower than at any time since 1912. "One consolation is," Mr. Appleton says, "that in view of all the circumstances, the membership figures might have been worse. There has been a great war, and in more or less associated countries, a series of disturbing revolutions, all of which have affected trade union possibilities and membership and instead of being back at the half-way house, the Federation might easily, as far as membership is concerned, have been back at its beginning. There are, however, signs of reactions and recoveries which should bring additional members and new strength to the Federation."

The Federation's receipts are a little less than they were in 1924—57,730*l.* 16*s.* 8*d.*, as compared with 60,952*l.* 0*s.* 11*d.* The further significance of these figures is better understood, Mr. Appleton points out, if it is remembered that the Federation, unlike most other organisations, has not raised the rate of its contributions. The year's outlays are also less. In Federation benefit the sum of 9,685*l.* 15*s.* 10*d.* has been disbursed. That is the smallest sum since the abnormal year of 1917–18, but it brings the total expenditure on benefit to date up to the considerable sum of 1,138,793*l.* 9*s.* 5*d.*, which, added to the present reserve fund of 149,941*l.* 14*s.* 11*d.*, makes a grand aggregate of 1,288,735*l.* 4*s.* 4*d.* of benefits paid or in hand, or 2,127*l.* 4*s.* 4*d.* more than the total contributions and entrance fees paid by affiliated Societies. "No other trade union organisation in this or any other country can show," it is claimed, "such good results."

A conference took place in London yesterday between the general managers of the various British railway companies and representatives of the railwaymen's trade unions at which the present very unsatisfactory economic state of the industry was unofficially and informally discussed,

PROGRESS IN BRITISH ROLLING-MILL PRACTICE.*

By T. W. HAND, M.I.Mech.E.

(*Concluded from page* 781.)

AT a somewhat similarly arranged plant not yet completed in the Lincolnshire area, another novel shearing system will be employed. This plant comprises a 40 in. × 9 ft. 6 in. slab mill, a 40-in. reversing plate mill with roughing rolls 12 ft. and finishing rolls 10 ft. long, and a single stand reversing mill with rolls 32 in. × 7½ ft. for light plates. This latter mill is so laid out that an additional stand of rolls may be arranged in tandem should future possibilities regarding output warrant it.

All mills are to be electrically operated, and but for the postponement of completion this would have been the first "all electric" large mill plant to be set to work in the United Kingdom. A novel arrangement of driving equipment has been adopted for these mills, two flywheel converter sets, each having four generators, being provided for working the three mills, the two converter sets being cross-connected in such manner as to permit of the combined flywheel effect being utilised to meet the demand of any particular mill. Plates from the cooling bank will be delivered abreast of the side-cut shears on to a castor-bed served by a "Thomson" plate-handling device. This is illustrated by Fig. 16, from which it will be observed that the principle involved comprises means for traversing a suspended magnet in two directions parallel and at right angles to the shear blades, thereby providing all the essential movements of the plate on the castor-bed realised by more arduous manual manipulation.

A plate mill plant laid down at the Clydebridge Steel Works incorporates many novel features, and is probably one of the most efficiently manned mills in existence, practically every known mechanical device for easing manual effort being incorporated. The mill is the first of its type in this country to be operated by a direct connected reversing type mill motor, the primary object of this being to retain the advantages incidental to speed adjustment obtaining on reversing mills. This motor can take peak loads up to 13,000 h.p.

Fig. 18 illustrates the latest plate mill plant laid down in this country, its construction and installation being now in process of completion. This plant comprises a 40 in. by 8 ft. 6 in. slabbing mill, a two-stand 42 in. by 9 ft. 6 in. reversing heavy plate mill, a 32 in. by 6 ft. 6 in. three-high light plate mill, and a chequer plate mill with rolls 6 ft. 6 in. long. The mills and all auxiliaries, excepting only the three shears at the heavy plate mill section, are electrically operated. These mills have been designed in full accordance with modern ideals, and incorporate in addition to the best of known practice, many novel features calculated to ensure rapid and economical production. Plates from ¼ in. to 2 in. thick and up to 8 ft. 6 in. wide will be produced.

The site available for this plant was to some extent limited, and inspection of the lay-out will indicate that the various units have been well arranged so as to provide ample space at all points essential to efficient production. This aspect is particularly emphasised in the spacious loading bay as compared with the congested area available for this purpose at many older plants. It will be observed that the chequer plate rolls are located in tandem with the light plate mill, the chequer plate mill being so designed that its rolls may be well ambushed when not in use. It might be mentioned that the complete development of this plant constitutes somewhat of a record, less than two years having elapsed since its conception, and during which period the whole site has been cleared of existing mill buildings and machinery, and new levels created.

Considerable pioneer work has been done by Messrs. Bolckow Vaughan and Company. Inspection suggests a tendency towards complete electrification of all mill plant at their Cleveland Works, the effective development of heat recovery from blast-furnaces, open-hearth and soaking pits, by the use of waste-heat boilers, having demonstrated that energy almost sufficient for all mechanical working of the steel is obtainable as a by-product of those processes incidental to its manufacture.

Fig. 21 illustrates the only comprehensive plant yet installed in the United Kingdom for production of large tonnage of small sections with the minimum expenditure of power, fuel, and labour in conversion from the ingot. This plant was laid down for a normal production of 40,000 tons per month, the whole of which must necessarily pass through the blooming mill illustrated. The latter takes a 7,000-lb. ingot, 21 in. square at base and reduces this to 7½ in. or 6½ in. square in 13 or 15 passes respectively.

It will be observed that the plant is arranged with great flexibility, permitting of a wide range of product for direct sale or feeding the merchant bar, strip, and wire rod mills illustrated.

Products of the blooming mill, such as slabs up to 18 in. by 6 in. and large blooms, are side transferred to No. 2 shear and discharged direct into trucks, whilst medium-sized blooms requiring good finish may be run forward to the two-stand 21-in. Morgan mill located in line with No. 2 shear. This mill will produce in closed gates blooms 5 in., 5½ in., and 6 in. square, direct from the cogging mill, and relatively small-edged slabs and large billets requiring specially good finish, previously passed through the first group of continuous rolls situate ahead of No. 1 crop shear.

21-in. Billet Mill.—It should be appreciated, however, that the principal producing unit is the Morgan continuous billet mill located in tandem with the blooming mill, this being designed to easily absorb the entire output of the latter.

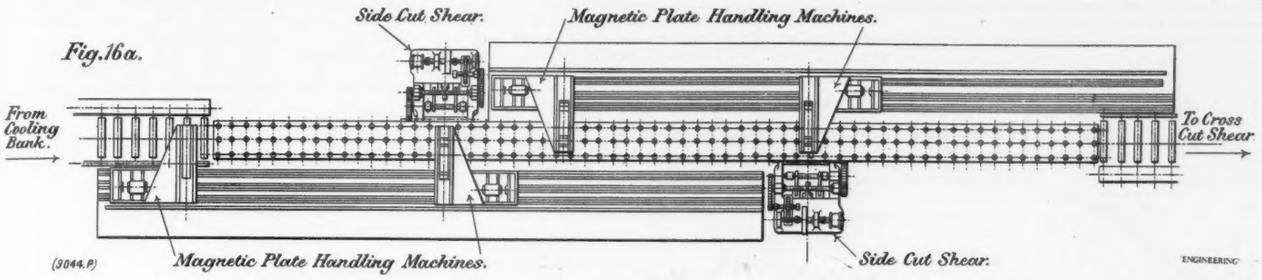
The first section of this mill comprises four stands of 21-in. rolls. These are arranged with three lines of passes, the near side taking a 7½-in. square bloom, and the far side a 6½-in. square bloom, producing respectively 4½ in. and 4 in. square billets. The centre pass line takes a 6½ in. square bloom and produces an 8 in. by 2 in. slab, or, if desired, still narrower slabs may be made by starting with a somewhat smaller bloom. Billets of the size above referred to may be side transferred immediately after leaving the 21-in. mill, or delivered straight ahead to a second group of continuous rolls 18 in. diameter for further reduction.

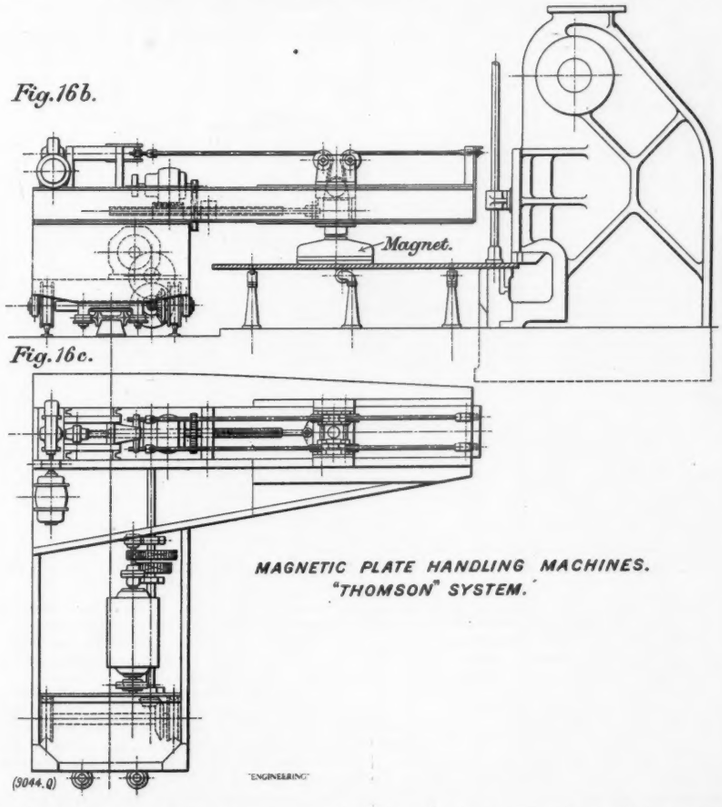
18-in. Billet Mill.—This mill will produce 3½ in., 3 in., 2½ in., 2 in., 1¾ in., and 1½ in. square billets, also a range of small slabs without change of rolls.

The product of this mill up to 3½ in. by 3½ in. billets is dealt with by a flying shear, which cuts up the billet into 15 to 30-ft. lengths, as this leaves the finishing stand of rolls the speed of delivery in the case of 1½ in. or 1¾ in. square billets being about 600 ft. per minute. The whole ingot length when sheared is automatically assembled by means of an ingenious arrangement of skew rollers, and receiving straight edge, before side transfer to the cooling bank.

A most important feature of these mills is found in the possibility of producing the smallest size billets without any limitation of output, the usual size being 1¾ in. square. This particular size of billet has been more or less standardised in America from consideration of utility, inasmuch as a 1¾ in. square section constitutes the midway point of reduction normally covered by hot-rolling—in other words, a 7,000-lb. ingot reduced to a 1¾ in. square billet, and this latter still further reduced to a No. 5 gauge wire rod, each representing about 100 elongations.

This system of billet production is practically





MAGNETIC PLATE HANDLING MACHINES.
"THOMSON" SYSTEM.

* Paper read before the Iron and Steel Institute, London, on May 7, 1925. Abridged.

universal in America, and accounts for about 80 per cent. of all small billets made in that country.

The advantage gained at the cogging mill is obvious, inasmuch as the smaller sizes which so seriously restrict output are absolutely eliminated.

Power Consumption.

Averages for Billet Mills.

From 34 units per ton for 1½ in. square billets } Main mill
to 12 units per ton for 4 in. square billets } motor.
3¼ units per ton all auxiliaries, excepting only the steam-driven flying shears.

The labour force for the cogging and billet mills with all auxiliary services, including soaking pits, billet banks, cranes, mechanical forces, &c., comprises 160 men for a single ten-hour shift.

The fuel consumption, which is, of course, limited to that required for the soaking pits, may be taken under present intermittent conditions of operation as about 168 lb. of producer-coal per ton of ingots.

2 in. by 2 in. to 5 in. by 5 in., and slabs may also be used for production of wide flats.

The mill will produce rounds from ½ in. to 2¾ in. diameter, all equivalent squares, angles up to 3 in. by 3 in., and flats up to 8 in. wide.

It will be observed from the lay-out plan that roller tables are provided for each of the four stands of the finishing mill, the rollers of these tables being ingeniously arranged in skew fashion, so as when reversed to cause the piece to hug the side of the table leading into the next roll guides, thereby eliminating manual manipulation.

Readily removable repeaters are also provided for the back side of the mill, these being used on all rounds not exceeding ⅜-in. diameter.

When working up to full capacity of the heating furnace, this mill will produce 30 tons per hour continuously, and is usually rated at about 12,000 tons of product per month of average sizes.

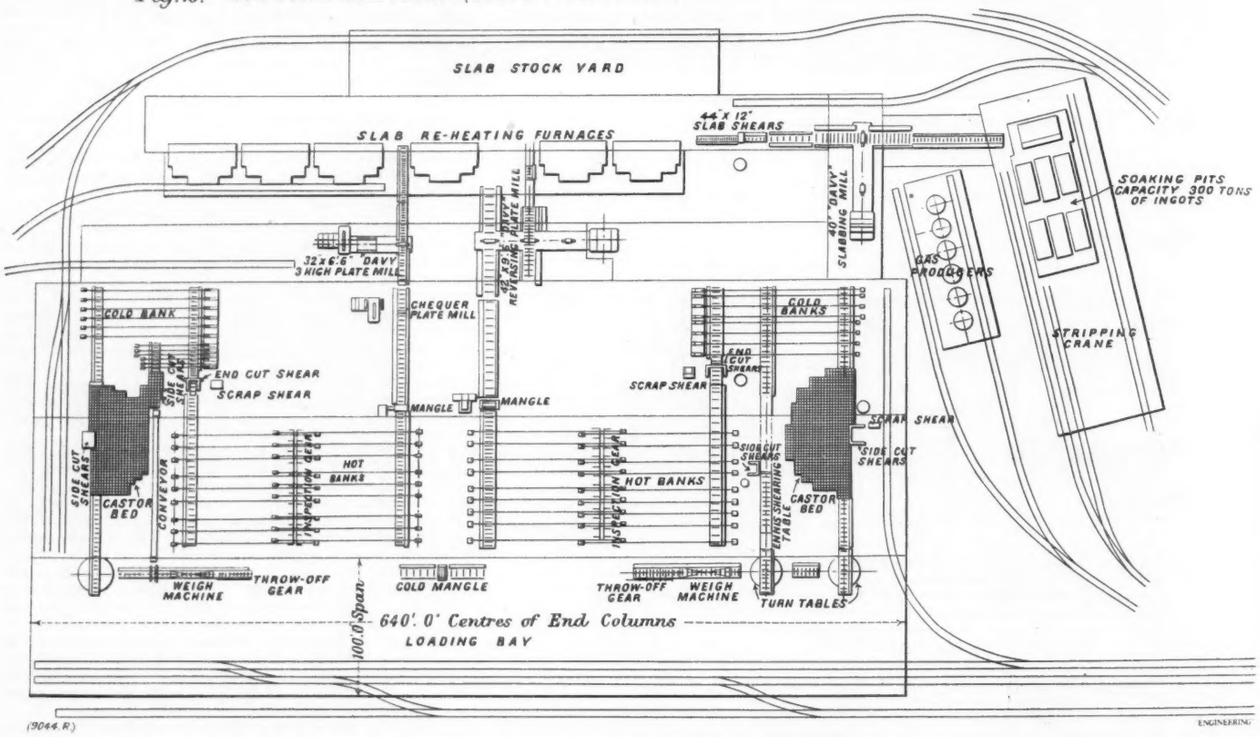
Forty-eight men per shift are required for complete

is divided into groups of purely continuous roughing and finishing rolls, with vertical edging rolls interposed. On leaving the last finishing roll, the strip is automatically turned and delivered through a vibrator in loop formation on edge to a slowly travelling apron conveyor moving in the direction of the coiling reels. This method of delivery permits of dealing with an enormous length in a relatively short space, and presents maximum surface to atmosphere, resulting in rapid cooling, at the same time imparting the colour finish usually desired on this product.

The forward end of the strip is entered direct to the reels located immediately beyond the conveyor above referred to, and after cooling is discharged through a slow-moving muffle conveyor, at the delivery end of which the coil is discharged on to trucks sufficiently cooled for man-handling if required.

The product of this mill may be despatched in complete coils or passed through uncoiling machines, and fed to rotary type shears for cutting into definite

Fig. 18. NEW PLATE MILL PLANT. (CONSETT IRON Co. Ltd.)



With the plant working at full capacity this would certainly be reduced to, say, 100 lb. of fuel per ton.

This mill layout is equally suitable for a high output of sheet bars, the usual arrangement being to substitute complete spare roll stands for the second group of continuous billet rolls, the entire change being made in about four hours.

Beyond bringing into action two sets of edging rolls at the 18-in. mill group, no change in mill operation is required for making sheet bar, this being cut up by the flying shear in exactly the same manner as billets are sheared, the product being automatically assembled in stacks equal to about three ingots by means of pinch rollers and a sheet bar piler, and thence transferred to cooling bank by overhead crane.

In view of the importance of the sheet and tinplate industry of the United Kingdom it is difficult to understand why sheet bars are still rolled here from relatively small ingots on reversing mills at a probable conversion cost from the ingot of 25*s.* to 30*s.* per ton, when our American friends have now for many years been rolling these on plants such as that described at a much lower figure, and this with wage rates and other costs very much higher than those obtaining in this country.

The advantages derived from rolling long lengths are well known, these being strikingly illustrated in the case of the merchant bar, strip and wire-rod mills, also comprised in the Templeborough plant.

These mills are each equipped with Morgan-type reheating furnaces adapted for billets 30 ft. long, and at maximum capacity will operate continuously on a fuel consumption not exceeding 150 lb. of producer-coal per ton of steel heated.

Merchant Mill.—Billets used in this mill vary from

operation of the mill, this number including gas-producer attendance, billet-yard men, mill operators, weighman, and labour concerned in handling the finished product.

Not the least important feature of this mill is the double mechanical cooling bed. Rolled bars are directed by means of a switch in the run-out from the last pair of finishing rolls alternately to one side or the other of the bed, on which they are mechanically stopped, cross-transferred, and assembled in multiples for delivery to the cold shears. The construction of the rocking racks of these cooling beds results in the rolled bar being contained in continuous V-notches throughout its 300-ft. length, and during the whole period of cross-transfer.

Moreover, as the piece is retained in the notches in opposition to gravity, ideal straightening conditions are ensured, and perfectly regular treatment given to every piece rolled.

On leaving the cooling beds, the pieces, as already stated, are mechanically assembled, cold-sheared in multiple lengths up to 75 ft. long, and discharged by mechanical push-off into bundling pockets mounted on weigh scales, and from these lifted by overhead crane direct to trucks or stock.

Strip Mill.—The mill illustrated receives billets from 1½ in. by 1½ in. to 3 in. by 3 in., also slabs, and has a range of product varying from 1 in. wide by 0·030 in. thick to 5½ in. by 0·092 in., the designed output being about 6,000 tons per month.

Forty-one men per shift are required for complete operation of the mill, this number including gas-producer attendance, billet-yard men, mill operators, weighman, and labour concerned in handling finished product.

It will be noted from the layout plan that the mill

predetermined lengths, these being assembled and bundled in accordance with trade requirements.

Rod Mill.—This mill, which is fed with billets 1¾ in. to 2 in. square by 30 ft. long, produces rods from 6-gauge to ½ in. diameter.

The mill works double strand, or, in other words, two billets are passed through the rolls simultaneously, the actual rolling period from the front end of the billet emerging from the furnace door to the outer end of the rolled rod, leaving the last finishing roll of the mill being about 50 seconds.

On normal production of No. 5 gauge wire rod from 1¾-in. square billets, this is equivalent to two 300-lb. bundles per minute, an output which can be maintained with perfect continuity—in fact, a production of 170 tons has been recorded over a single 11-hour shift.

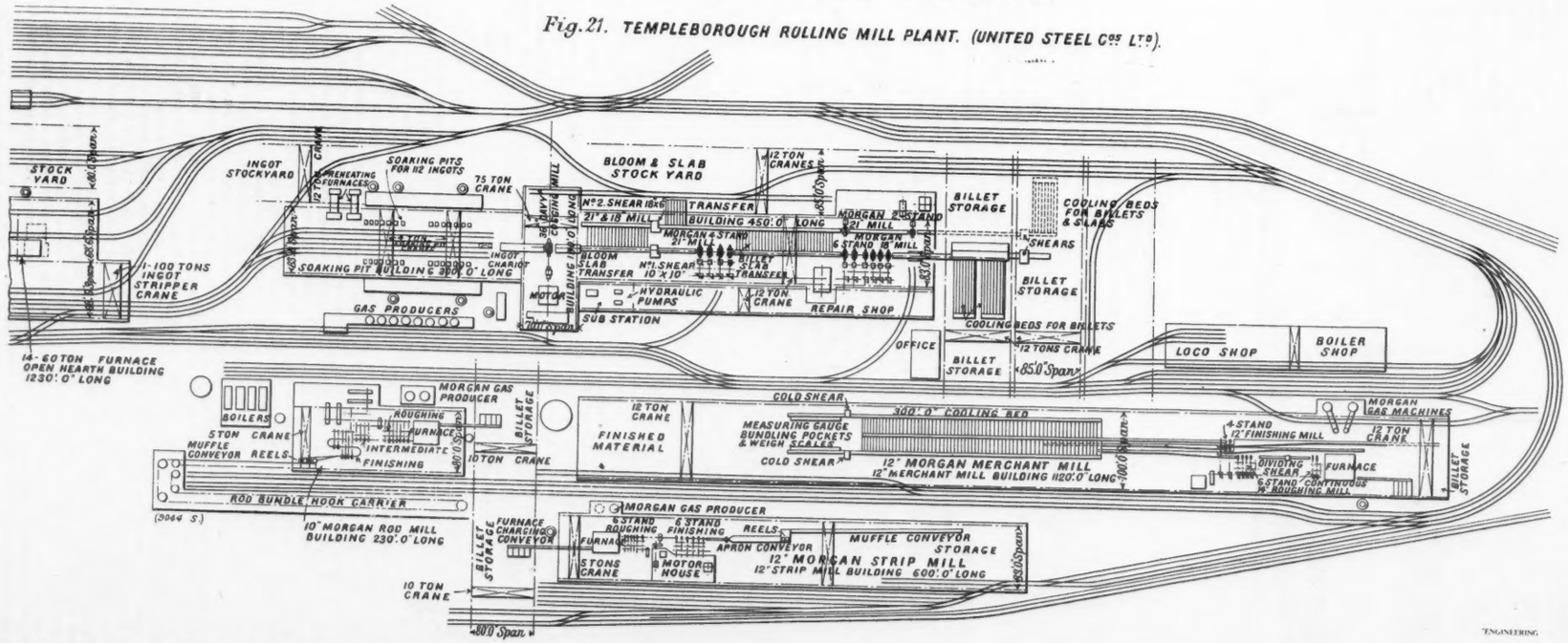
It will be observed from the layout that the complete mill comprises 17 stands of rolls, these being conveniently grouped to allow of flexibility in operation, and a flying shear located immediately ahead of the seven-stand roughing mill for the purpose of cropping the front end of the bar so as to ensure a square solid and hot end for entry into the intermediate train.

On leaving the last finishing roll the rod is directed by means of automatic switch devices through closed guide pipes containing flowing water to one or other of the four rod reels, the bundle thence being mechanically deposited on a slow-moving muffle conveyor for discharge to loading dock.

On reaching the discharge end of the muffle conveyor the bundles are automatically picked up by an ingeniously arranged rod bundle carrier, which travels continuously around the loading dock, the length of this latter and rate of travel being so arranged as to

BRITISH ROLLING-MILL PRACTICE.

Fig. 21. TEMPLEBOROUGH ROLLING MILL PLANT. (UNITED STEEL Cº LTD).



ensure the bundles being sufficiently cool for man-handling on reaching the point at which these are loaded into trucks.

In rolling wire rod the elimination of oxidisation is a vital consideration, and a little reflection will show that this is carried to the fullest possible extent in Morgan mills of the type referred to. In fact, after leaving the roughing mill, very little is seen of the rod until this emerges from the final guide on to the coiling reel, and, moreover, as two-thirds of the billet still remains in the furnace at the time the front end reaches the reel, it will be readily understood that uniform treatment is assured throughout the whole length of the rod, both front and back ends being rolled at the same temperature.

On normal production this mill will produce 15 tons per hour continuously, and requires a complete labour force, including all services, of 45 men per shift.

Through special considerations obtaining at the time the plant was installed, this mill was arranged with engine drive, and comparative power consumption with the other mills of the plant is not readily available. It may be taken, however, from recorded data concerning identical mills in America, as about 100 units per ton, this figure including main mill and all auxiliary motors. The yield of good rod averages 95 to 97 per cent.

Skelp Mill.—An interesting feature of a skelp mill recently installed in this country is found in the rotary flying shear, which cuts up the skelp into predetermined lengths as this leaves the last stand of the finishing mill, and delivers them on to the discharge conveyor, at the outer end of which a set of pinch rollers assemble the whole billet length in pile formation for transfer across the mechanical cooling bed. On reaching the outer end of the cooling bed the piles are weighed, bundled and mechanically discharged into bunkers, from which the overhead crane removes them direct to trucks or stock.

Fig. 23 illustrates a unique type of Morgan mill installed a few years ago in Newport, Monmouthshire.

In designing this mill, the originators had in mind the more varied demands of this country, the result being that plant was developed which combined the essential features of strip and skelp mills. It will be observed that the product of the mill can be delivered to strip coiling reels or skelp cooling bed in accordance with requirements, the handling and storage facilities of the building being suitably arranged for dealing with both products. The output of this mill on 3-in. and 4-in. skelp has reached 200 to 220 tons per eight-hour shift, such tonnage being limited only by furnace capacity when handling relatively large products. The net yield from cold billets after crediting value of scale, scrap, and defectives is 97 to 98 per cent.

No opportunity is missed as regards realising the full possibilities of this plant, recording instruments being used which provide an absolutely reliable record of every operation, the power peaks on the chart clearly indicating the degree of uniformity maintained in heating the billets and feeding these into the mill.

The importance of regular feeding cannot be over-emphasised, as inspection of Fig. 24 will show. This is a reproduction of a chart actually taken from the finishing mill motor when rolling $2\frac{1}{16} \times 0{\cdot}062$ in. strip at high speed. It will be observed that the gaps between the billets, or, in other words, the depressions in the curve, average, say, 20 per cent. of the total rolling period, but that in some instances this is reduced to approximately 5 per cent., indicating that in such cases billets are fed into the rolls approximately end to end. Other records clearly refute adverse criticism occasionally made concerning mechanical efficiency of necessarily complicated mill machinery. Running light at full speed this mill with fifteen sets of 12-in. rolls absorbs less than 200 kw., roughly 10 per cent. of the total rolling load, a surprisingly low figure when taking into account the absolute roll rigidity required in rolling such fine gauges as are produced.

The pure continuous mill has one great and fundamental advantage, viz., that when fixed close to the door of the heating furnace, the time period from the furnace to the last or finishing pass is exactly the same for the first and last end of the billet, regardless of its length and weight, and consequently any length can be finished, and the same weight and temper of the finished piece maintained from end to end, results unattainable in any other type of mill. Moreover, extended study and application of the principle of continuous rolling is resulting in the discovery of such further possibilities in the combination of continuous and semi-continuous roll trains, that the scope of this type of mill is being constantly widened.

The old belief that anything capable of turning round was good enough for rolling-mill work is fast disappearing, and scientifically designed machinery is now well established in the leading steelworks of most countries. Such design necessarily embraces the vital considerations of selection of materials of construction, accurate machining of working surfaces, and possibly more important still, adequate lubrication, with total enclosure, wherever possible, of lubricated surfaces. These provisions are necessarily reflected on the running of the mill, it now being quite possible to run a complete cogging mill train and its electrical equipment with a power consumption of about 220 kw. at light load, probably at least two-thirds of such power being absorbed by the flywheel converter set. The advantages resulting from complete electrification of main and auxiliary drives have been so fully discussed that further comment would appear to be superfluous.

ABRASIVE MATERIALS.—*Abrasive Materials in* 1923, by Mr. F. J. Katz, a publication issued by the Geological Survey of the U.S. Department of the Interior, is divided into two parts, the first dealing with natural abrasives occurring in the United States, and the second with artificial abrasives manufactured in the United States and Canada. It is stated that during 1923 the abrasive industry as a whole enjoyed greater general prosperity than was the case during the two preceding years. The total output of artificial abrasives as represented by aluminium oxide, silicon carbide and metallic abrasives, amounted to 80,769 short tons in 1923, an increase of some 27,000 tons over the previous year; the value totalled 8,780,000 dols. in 1923, as compared with 5,690,000 dols. in 1922.

BRITISH ROLLING-MILL PRACTICE.

(*For Description, see Page* 811.)

Fig. 23. MORGAN CONTINUOUS 12" HOOP & SKELP MILL. WHITEHEAD IRON & STEEL Co. LTD. COURTYBELLA WORKS. NEWPORT.

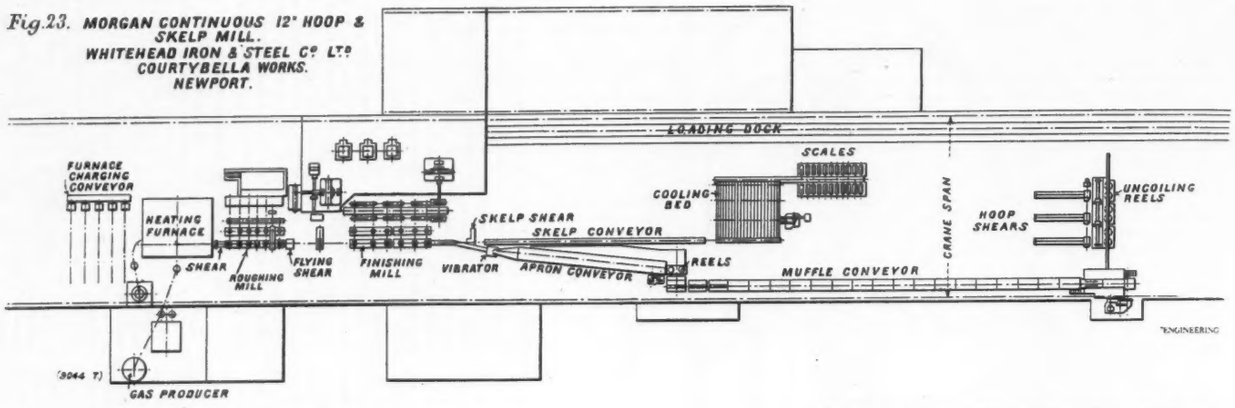
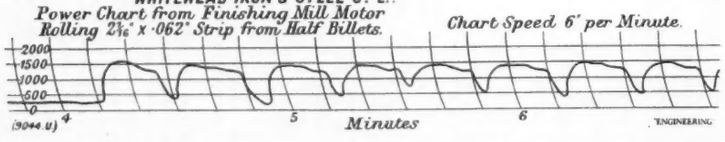


Fig. 24. MORGAN CONTINUOUS 12" HOOP & SKELP MILL. WHITEHEAD IRON & STEEL Co. LTD. *Power Chart from Finishing Mill Motor Rolling 2⅛" x ·062" Strip from Half Billets. Chart Speed 6" per Minute.*



THE DOUBLE-WIRE SYSTEM OF MECHANICAL SIGNALLING.*

By R. S. GRIFFITHS.

MY object in this paper is to endeavour to prove that the double-wire system of mechanical signalling has advantages over the system at present in use in this country; and I ask your indulgence if I repeat some of the special claims previously urged in favour of the double-wire system. I feel that so wide a subject and so apparently drastic a change in mechanical signalling methods should as a whole be briefly compared with the system at present in existence.

This consideration, can, I think, be regarded to the best advantage if viewed from the following aspects:—

(1) Does the double-wire system in any way imperil the high standard of safety obtained with the present system?

(2) Is the double-wire system an economical proposition?

(3) What advantages, other than those, if any, obtained under (2), does the double-wire system offer over the present methods?

Taking the first aspect, what is the basis of the splendid safety existing to-day?

(*a*) That a signal to proceed shall only be given when any points over which it reads are correctly set, and if they are facing points, securely bolted; further, that no conflicting signals shall be given.

The first two considerations are met by signal detection, the third by interlocking. The last point can be dismissed at once, as the interlocking on a double-wire frame is in every way the same as that on the present types of locking frames.

The first two conditions are met in the same way so far as signal detection is concerned, but the double-wire system provides an additional safeguard as, on the point lever, the paying out wire is a form of return indication, showing that the appliance worked by the lever is functioning correctly and the operating connections are intact; and it thereby resembles in some respects, the return indication on a point lever of a power installation.

(*b*) That facing points shall be held immovable by each and every vehicle passing over them.

This condition can be met in both systems by the same means, namely, by lock-bars and track circuits and efficient facing point locks.

(*c*) That the signal arm shall always follow the action of its operating lever, except when the operating wire breaks, when it shall return to, or remain at, "danger."

Here, I think, the double wire system provides greater safety than the present single wire gravity return system. Accidents have happened before to-day through signals being held "off" by jambed operating wires, by the freezing of the arm spindle or other fitting, or by snow; but with a pull to "danger" wire the arm is more likely to return to "danger" when the operating lever is moved from "clear" to "danger." Several methods of insuring against a fracture of the pull to danger wire have been described in previous papers, and I shall show an alternative method later.

Again, double-wire signal operation is immune from false "clear" indications due to accidental or malicious interference with the pulling wire, a danger ever present with single-wire operation, where any force exerted on the single-operating wire when the lever is normal will cause a signal arm to droop, if not come altogether, to the "proceed" aspect. From this I think it will be admitted that, not only is no sacrifice of safety made by the use of double-wire operation, but greater safety is obtainable.

Taking next the question, "Is the double-wire system an economical proposition?" This is perhaps the most difficult problem, due to the large amount of mechanical signalling already in service, but I venture the suggestion that if we were starting afresh, with both systems available, double wires would stand a good chance of being selected. It is hardly fair to argue that a lot of wires about a station are a nuisance, because on the Continent one of the things that struck me was the absence of any wires. Further, I think the same argument could be used about rods, entailing as they usually do, a large amount of timber protection. Generally speaking, I think signal wires can more easily be kept out of the way than rods, and point wires would run in the same space as signal wires do.

However, for the sake of comparison, let us divide the economic question into sub-divisions of—(*a*) Cost of apparatus and installation; (*b*) cost of maintenance; (*c*) operative costs.

Taking the first of these sub-divisions, the double-wire system would increase the cost of signal connections, but would not, of course, double it, as it is well known the first wire is more costly than additional ones in the same run. Again, it is probable that the interlocking frame with its protective devices would not cost less than the types at present in use, and, very possibly might be slightly more expensive. On the other hand, point connections with the double-wire system should be cheaper, as wires carried on the same stakes as the signal connections must be cheaper than rods with their rollers and roller stools. This lower cost naturally becomes more pronounced as the distance between lever and points increases. Further, economical working of points and point locks can always be employed owing to the greater power obtainable with the double-wire locking frame.

It is somewhat difficult to give actual figures as, to my knowledge, no definite costs have been got out for installing any one station by the two systems, but a saving of 20 per cent. would, I think, be obtainable by the double-wire system. If the double signal lever method is employed, a further saving could be effected.

With regard to maintenance costs, again no figures can be quoted, as no double-wire installation exists yet in this country. However, if one includes painting as maintenance, this expense alone must be considerably lower with the double-wire system. Again, wheels are cheaper than cranks. Lifting of rods, due to the raising of the track, is practically eliminated. Alterations to connections, due to modifying the station lay-out, would be less, and can be done more expeditiously. One type of operating connection reduces the amount of stock held for repairs, and thus locks up less money; repairs due to derailments would be largely eliminated, and when they did occur, would be cheaper and quicker to renew, so that generally, maintenance costs would be very considerably reduced by employing the double-wire system.

The smoother working obtainable with double-wire operation, particularly of signals, due to the elimination of excessive weights, makes for longer life of the operating connections. Our present signal operation results in the lever and the signal fittings being hammered out, not worn out.

As to operative costs, if full advantage is taken of the increased power available by the double-wire system, many cases would be found of one cabin being able to do the work of two, lever pulls would be saved by economical point lock working, better results obtained by the lightening of signalmen's duties, as towards the end of his shift he would be less tired, and consequently his brain more active. This last condition is of real value, as frequently mishaps have resulted from loss of mental activity following from bodily weariness.

Again, I believe that a signalman is paid 1 mark for lifting the catch of a signal lever and letting it fly back, in short, to jar the appliances continually; it is surely better to make him pull the signal back. He is then paid to operate the signal properly, while the total physical effort of pulling "over" and pulling "back" a signal is not more than pulling "off" a signal plus an amount of weight than can be dispensed with, and doing practically no work to return it to "danger."

We now come to the last aspect, briefly summarised as "other advantages," and I take as the first of these, that it enables automatic compensation of signal operating wires to be employed.

Automatic compensation of signal wires has tested the ingenuity of engineers from the earliest days of signalling, but has as yet proved insurmountable with a single-wire system. Its advantage, particularly where signal cabins are switched out for periods of 12 hours and over, is, I think, unquestioned, as it is the only solution for maintaining the same aspect under all variations of temperature. From the subsequent description of a double-wire compensator you will see that it is not a complicated piece of apparatus and that it functions correctly both when the lever is normal and when it is reversed.

Compensation of point rods is to-day quite satisfactory, but theoretically, shade should be taken into account in determining the position of the compensators, and there are sundry other questions to be considered including the provision of two compensators for cross-over roads, and the varying length of the arms of the compensator cranks to suit various lengths of rod. For instance, a different length of arm should be used for a rod 350 yards long to that for a rod of, say, 150 yards long, due to the greater length of expansion in the longer rod.

With the double-wire system, however, no such questions arise. One compensator only is required; it can be fixed where most convenient, and will take care of any length of connection within operating distance.

Next, double-wire signal operation enables a more regular "clear" aspect to be maintained, due to the

* Paper read before the Institution of Railway Signal Engineers, March 11, 1925. Abridged.

type of signal drive employed, and for signals situated at some distance from the cabin by the automatic compensators referred to above. Everybody, I am sure will agree that the more uniform the signal aspects can be, the better it is for the engine driver, eliminating as it does all doubt in his mind as to whether it is in the "danger" or "proceed" aspect.

Another advantage is that the double-wire system makes mechanical three-position signalling an accomplished fact. The next advantage I shall urge is one likely to raise some criticism, namely, that it makes point trailability a safe and economical proposition. In support of this, I believe I am right in saying that on the Continent, where it is in general use, no railway accident has ever been traced to this facility.

The operation of trailable points from an interlocking frame calls for certain additional conditions to be met, that do not exist where points are of the non-trailable type, as for instance :—

(1) The signalman should have a visible warning that points have been trailed.

(2) The levers of any signals reading over points should immediately become locked normal when such points are trailed, and, further, should remain so until the points have been restored to their correct position ; also, of course, any other point lever affected.

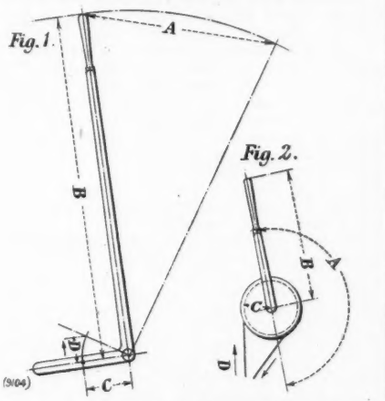


FIG. 1. COMPARISON OF VARIOUS MECHANICAL LEVERS.

Lever.	A.	B.	C.	D.
	ft. in.	ft. in.	ft. in.	in.
Messrs. Stevens and Sons, 1880..	3 6	7 10¼	1 11¼	10
Messrs. Saxby and Farmer, 1888	3 0	7 0	1 1½	6
L.N.E.R. (G.C. Section), 1924 ..	3 2½	6 9	1 3½	7½
L.M.S.R. (Midland Section), 1924	4 0½	4 3	0 6½	6½
Westinghouse Brake and Saxby Signal Company, 1924 ..	3 9	6 6	0 10½	6
Westinghouse Brake and Saxby Signal Co., double wire, 1924..	7 10½	2 6	0 5½	18

(3) Means should be provided to enable the signalman to restore all trailed points to their proper co-relationship with their operating levers ; and this, of course, without his having to leave the signal cabin for the purpose.

(4) Means of determining when points are trailed for the purpose of recording incorrect working ; and, if necessary, apportioning the blame.

All of these conditions have been provided for in the apparatus being supplied to a Colonial railway. It should, of course, be realised, that trailability is provided not as a normal working, but to prevent damage of the apparatus when through inadvertence or carelessness, points get trailed ; and it is particularly advantageous where, owing to distance from a district repair depot or infrequent train service on the section, damage to the operating connections through the trailing of a pair of points cannot be quickly repaired.

Such a case is a single line passing station on up-country lines on Colonial or Indian Railways, which do not warrant by their traffics an elaborate signalling system. At such stations, starting signals can with impunity be dispensed with, and a safe but economical signalling system provided, points and home signals being operated from the platform.

Further, I submit that the double-wire system is a better mechanical proposition than the methods in use to-day. I have carefully studied the question of leverage and work to be done by the interlocking frame between the year 1880 and the present time. From this research it appears that (1) the distance at which facing points are worked has increased by over 100 per cent., viz., 150 yards to 350 yards ; (2) locking bars have increased from say, 30 ft. long to 50 ft. long, that is 66 per cent. ; (3) rails have increased in weight from about 80 lb. per yard to 95 to 100 lb. per yard, and switches correspondingly ; (4) detector connections have increased to include the plunger as well as the switches.

To meet this extra work to be done, the rod connections have been fitted with anti-friction traversing rollers—certainly a considerable gain, but what about the levers ?

Fig. No. 1 shows the dimensions of :—

1. Stevens and Sons' lever 1880
2. Saxby and Farmer's lever 1888
3. L. and N.E. Railway (Great Central Section) 1924
4. L.M. and S. Railway (Midland Section) 1924
5. W.B. and S.S. Company, Limited, 1924 type 1924
6. W.B. and S.S. Company, Limited, double wire locking frame.

and indicates that to meet the greatly increased work to be done little improvement has been made in the locking frame, while the double wire frame gives far greater power than any of the others.

Next, is half-pulling and half-pushing a rod 350 yards long, to exert a force that distance away, as sound a mechanical proposition as pulling a rope round a pulley ? In the first case you have to move a weight of—

2,100 lb. if it is tube weighing 6 lb. per yard,
3,200 lb. if it is channel rod weighing 9 lb. per yard,
or 4,300 lb. if it is solid rod 1¼-in. diameter ;

which must be supported and guided or held against buckling by 175 supports ; and there must be at least 12 pin centres of joints and 5 centres of cranks, including the two cranks in compensators. In the second case you have 700 yards of No. 8 solid wire, weighing approximately 150 lb. led round nine pulleys, including a compensator fixed outside the cabin, or seven pulleys if the compensator is fixed inside the cabin, the wire being supported on 70 pulleys.

Then, how do the two-lever movements compare ?

With the ordinary mechanical frame, when pulling over the lever, the signalman has the assistance of his weight in addition to the force he can exert by pulling, but in putting back from reverse to normal, does not have any assistance, but must rely solely upon his own strength ; and often the lever is not in the most advatageous position for him to exert his power. With the double wire frame each full stroke enables both pulling and pushing to be exercised, and each in their most advantageous position, particularly at the commencement of their stroke when usually the lever is the hardest to work. There is one question that must not be overlooked, and that is that where compensators are fixed in point connections, they are always in a position to exert force on these operating connections, and that when one wire breaks, all this force is transferred to the other wire and the appliances which are connected to it at each end ; and this is somewhat of an additional risk, over what is found with rod working, where the compensator does not exert any force on the connections.

It will be realised that if the signal is "off," the points are held against movement, both by the detector connections from the switches and the detector connections on the plunger. Further, at rest it would be the retaining wire on which the strain would be, and therefore the one likely to brake ; and a safety catch is provided for this purpose in the point operating mechanism. Finally, if the train were passing over the points, the locking bar would be held against lifting. If the wire breaks during the movement of the lever, the compensator would return the points to the position they last occupied, and the signal detectors would be fouled for any other route. An additional catch is therefore provided on the lever to prevent its being moved further after the wire breaks. It should, however, be realised, that compensators are not necessary in connections of less than 250 yards or 300 yards. There is, I think, a considerable gain for the double-wire system in that it provides a long stroke on the operating connections at the lever. It is open to comment whether it is a good principle to provide only 5 or 6 in. at the lever tail, and need 8 to 10 in. at the points some 350 yards away. Is it not better to provide 18 in. at the lever and still require only 8 or 10 in. at the points ?

Summing up, I contend that the double-wire system has distinct advantages over the methods in use in this country, both on the safety side and mechanically ; and is distinctly a more economical proposition both in first cost and maintenance.

I would like to emphasise the fact that, owing to its unit construction principle, the system can be effectively combined with any mechanical system to meet conditions with which our present methods will not cope.

In this respect there are two outstanding instances, viz., long distance operation of points, and automatic compensation of signals. Taking the first of these, it is possible to attach to a present-day mechanical frame double-wire point levers for operating points beyond the distance at present permissible or considered desirable by the rod method, and such points, if required to be fitted with a lockbar and point lock may be economically operated. Thus, points up to 600 yards from a box may be operated by double wire, leaving those of 350 yards or under to be worked by the rod method, without presenting any difficulty in effecting the necessary interlocking between both types of levers. I am inclined to think however, that after some short experience with the double-wire lever, the signalman would commence agitating for double-wire operation of the remaining points, on account of the easier working obtainable by this method.

The second instance, viz., automatic compensation of signal connections would apply particularly to long-distance signals such as distant or slotted signals, and with even more force to the outer and warmer system of India, where two single wires, calling for frequent adjustment, due to variations of temperature affecting their operation, if trouble is to be avoided, are replaced by a double wire connection automatically kept in adjustment. This would not increase the number of control wires, and would undoubtedly improve the signal aspect, and lighten the pull. Further, the disadvantage accruing to a mechanical slot on such a signal is avoided by the design of the double signal lever, which prevents the operating wires of the distant arm being connected to the distant lever unless and until the outer signal lever has correctly operated the outer arm*

THE ECONOMICS OF GAS PRODUCTION ON THE THERMAL BASIS.†

By GEORGE EVETTS, M.Inst.C.E.

THE passing of the Gas Regulation Act, 1920, has enforced a new basis of comparison in gas production, distribution, and finance. The Standard of Calorific Power Order made the procedure so simple that many undertakings accepted the calorific standard, which conferred substantial benefit to those who were in a position to take advantage of it, and whose candle-power standard was 14 or over. It is clear now that the universal standard of 500 B.Th.U. or the special calorific value prescribed in the respective Acts of Parliament of the pioneers did not give the necessary elasticity to enable an undertaking to get down to rock bottom in costs of production and supply. Immediately the need for elasticity in manufacture became appreciated and recognised, it was apparent that the volume basis of sale must give way to the conception of selling thermal units in a more or less condensed form, leaving the strength to be settled by each individual supplier. There were some who preferred gas still sold on the volume basis at a guaranteed strength, using the standard therm price only as a medium for the calculation of dividends, but this method would have destroyed the element of simplicity which now exists.

The therm provides the universal standard of comparison, and is the basis to which all costs must ultimately be reduced. In dealing with upwards of 90 cases of applications for Section 1 Orders, the author has formed the opinion that, broadly, the volumetric consumption increases as the calorific value decreases. The basis of all calculations, therefore, is the demand for thermal units ; but, having got so far, the gas-maker cannot dissociate the volume from his considerations. The manufacturer of gas must produce a predetermined volume, and the distributor is called upon to propel this volume up to the point of ignition, with a certain flexibility at that point, but very little flexibility between that point and thé gas works. In the gas works, the producer is given a large range in the carbonising plant, both in volume and strength ; but at this point the flexibility ends when considered on the volume basis. Exhausters, washers, scrubbers, purifiers, gasholders, and works mains are limited in regard to volume. Taking the gasholders as a case for comparison, assume that the maximum daily demand is 10,000 therms (1,820,000 cub. ft. of 550 gas), gasholder storage of 1,600,000 cub. ft. would represent 8,800 therms, or 88 per cent. of the maximum day, with a 550 B.Th.U. declaration ; but if the quality were lowered to 400, the thermal storage would be reduced to 6,400 therms, or 64 per cent. of the maximum. In order to reach 88 per cent., as before, additional storage of 2,400 therms, or 600,000 cub. ft., would be necessary—costing about 15,000*l*. This would add 1·4*d*. per therm to the capital cost per therm sold per annum (based on 250 maximum days per annum). The same would apply to a lesser extent to the other items of plant mentioned.

In the distribution plant the volume of gas to be

* The Author then proceeded to describe the various double-wire system appliances, shown by the Westinghouse Brake and Saxby Signal Company at Wembley last year, most of which were described and illustrated in our issue of August 1, 1924, page 163.—ED. E.

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handled would also be increased, with the added disadvantage that the specific gravity would be higher; and the combined effect might be that mains would need to be increased in size, with the result that additional capital charges would more than neutralise any saving effected in manufacture by the reduction in calorific value.

The following factors must influence the choice of the declared calorific value, whether it be the first or a subsequent change: (1) The grade likely to give most satisfaction to the consumers; the special demands (if any) of trade and industry; (2) the class or classes of coal available, and the relative prices delivered; (3) the relative values of coal, oil, and residual products; (4) the capacity, type, and condition of the carbonising plant, viz., the efficiency; (5) the capacity of the remaining portions of the works plant; (6) the capacity and condition of the distribution plant; (7) the latest developments in carbonising plant and manufacturing processes; (8) the operating costs of the various types of manufacturing plant, either existing or proposed; (9) capital costs and rate of interest on money in cases where new plant is under consideration.

The Satisfaction of the Consumer.—The experience of the past few years has enabled many companies to gauge accurately the calorific value which is most acceptable to the consumers. In deciding upon a calorific value it must be assumed that the demand in thermal units will be fixed, and independent of the grade; the efficiency of the appliances is constant within wide limits of value, and therefore no consideration of increased or decreased total sales should affect the decision. The financial effect of this is to stabilise the standing charges per therm, whatever may be the declared value.

The Class of Coal Available.—The question of coal must be associated with the values of residual products and the type of the carbonising plant. If cheap coal is procurable from neighbouring coalfields, and the plant is capable of dealing with such coal, then the volatile matter and ash content compared with the price is a useful guide only if the coke yield is satisfactory in amount and quality. As the value of residual products gets less, so does the gas-producing qualities of the coal become of increasing importance. For instance, if 20*s.* per ton of coal carbonised were to be obtained for residual products in the case of either of two coals, then a good coal at 30*s.* producing 70 therms would be less advantageous than poor coal at 26*s.* producing 60 therms.

Relative Values of Coal, Oil and Residual Products.—The receipts for coal, tar, liquor compare very unfavourably with 1923. The amount of tar and liquor produced per ton of coal is of comparatively minor importance in the cost of gas, though the prices received can be by no means neglected, seeing that the net receipts amount on the average to ½*d.* per therm.

In cases where the residual products yield is stable in quantity, the financial result depends on residual prices; the usual return from by-products may vary from 50 to 80 per cent. of the net coals, dependent on the selling prices. In these circumstances, it is clear that, in the case of coal gas, the cheapest method of manufacture is that which produces the largest number of therms per ton of coal (leaving water gas reactions or any steaming or similar combination out of the matter); and such method would cheapen costs in so far as the amount of solid fuel dealt with (coal and coke) is accordingly reduced. It may be accepted without investigation that, in normal times coal gas is cheaper than water gas, and a low-grade gas is more costly to produce per therm than a high-grade, if the lower grade is a result of water gas admixture, either blue or carburetted. In the case of steaming, the thermal increase is made at the expense of the coke yield, but at no cost for wages, very little for repairs, and only a small addition for fuel in the absence of waste-heat boilers.

With any given price of coal complete gasification will not pay (taking only net materials into consideration) if more than 60 per cent. is returnable for residual products. This figure is based on the following assumptions:—

(1) That the fuel for carbonising in one stage is paid for by the tar, &c., from the process.
(2) That 180 therms per ton of coal are obtainable from complete gasification, and 70 therms from retorting.

180 represents 100 per cent. of cost of coal.
70 represents 39 per cent. of cost of coal (*i.e.*, net coals).

In the same way it can be deduced that, with coke standing at or above 80 per cent. of the price of coal per ton, it does not pay to make water gas, basing the make at 42,000 cub. ft. per ton for generators and blowers. As a general rule water gas does not pay if 55 per cent. or more of the cost of the coal is obtained from residuals.

Cost of Blue Gas and Carburetted Water Gas.—At first view carburetted water gas is much more costly than blue gas, but the net materials *plus* wages do not represent the total cost of these gases. Given a carburetted plant it is cheaper to make carburetted gas, but if the gases can be made in separate plants, the respective efficiencies must be considered. Table I below shows how the costs of blue and carburetted gas would compare if all factors are introduced. The coke figures and oil figures of yield are taken from Dr. Parker's paper on "The Production of Different Grades of Gas," read before the North British Association of Gas Managers in 1924.

Each penny reduction in the gallon of oil would reduce the cost of carburetted gas by 0·4*d.* per therm. Each 2*s.* per ton in the value of coke accounts for 0·16*d.* per therm in the value of blue gas, or 0·08*d.* per therm in the oil gas; or 10*s.* per ton reduction in coke has only the same effect as 1*d.* per gallon in oil. The effect of 1*d.* per gallon drop in oil and 6*s.* per ton in coke would bring the coal gas equal in cost to carburetted water gas, having regard to the increased cost of coal gas.

To sum up briefly, therefore, it is safe to assume that on present costs, (*a*) coal gas is cheaper than either blue or carburetted water gas; (*b*) carburetted water gas is cheaper than blue gas, into the gasholder; (*c*) complete gasification at 180 therms per ton is equivalent to coal gas when 60 per cent. of the cost is obtained from residual products (after adjusting for fuel for carbonising in the former); (*d*) the cheapest coal gas to make is that giving the most therms per ton of coal in normal circumstances; (*e*) the above factors tend to produce cheaper costs in higher values; (*f*) low coke prices tend to lower calorific values.

The Capacity and Type of Existing Plant.—The maximum production of therms per ton is not always the cheapest method of production when everything is considered. One therm of gas is as valuable as ¼ cwt. to ¼ cwt. of coke, as it is produced

TABLE I.

—	Blue Water Gas. 840 Cub. Ft. 292 B.Th.U. = 2·45 Therms.			C.W. Gas. 1,000 Cub. Ft. 483 B.Th.U. = 4·83 Therms.			Typical Coal Gas.
		Per 1,000 Cub. Ft.	Per Therm.		Per 1,000 Cub. Ft.	Per Therm.	Per Therm.
	d.	*d.*	*d.*	*d.*	*d.*	*d.*	Coals. *d.*
Coke, 36 lb. at 30*s.* ton ..	5·8	6·91	2·37	5·8	5·8	1·20	5·00
Boiler fuel, 10 lb. at 20*s.* ton .. (Not necessary if waste-heat boilers.)	1·1	1·31	0·45	1·1	1·1	0·23	—
Oil, 1·84 gallons at 5¾*d.* ..	—	—	—	10·6	10·6	2·19	—
Wages and salaries	3·0	3·57	1·22	3·0	3·0	0·62	0·80
Purification	0·3	0·36	0·12	0·5	0·5	0·10	0·11
Repairs to water gas plant ..	2·0	2·38	0·82	2·0	2·0	0·42	0·85
Repairs to general plant ..	3·4	4·05	1·39	4·0	4·0	0·83	0·85
	15·6	18·58	6·37	27·0	27·0	5·59	7·61
							Residuals.
Less oil, tar, 0·2 gallons at 3*d.*	—	—	—	0·6	0·6	0·12	3·20
	15·6	18·58	6·37	26·4	26·4	5·47	4·41

Each gallon of oil adds $\frac{2·38}{1·84}$ therms = 1·29 therms.

TABLE II.—NET COAL COSTS.

No.	Method of Carbonizing.	C.V. of Gas. Gross.	Gas per Ton. Therms.	Coke for Sale. Cwt.	Tar. Gallons.	S/A. Lbs.	Net Coals per Therm. A.	Net Coals per Therm. B.
							d.	*d.*
1	Verticals, very light steaming ..	500	57	9·5	15	34	2·53	2·91
2	Verticals, steamed	400	95	6·7	20	42	1·82	2·02
	Extra 38 therms obtained for (per therm)	..	..	..	..	..	0·75	0·68
3	Verticals, no steaming	544	71·3	9·25	9·3	16·3	2·48	2·75
4	Verticals, 20 per cent. steaming ..	460	103·8	7·5	12·4	21·2	1·89	2·04
	Extra 32·5 therms obtained for (per therm)	..	..	..	..	..	0·57	0·52
5	Horizontals	600	58	8·1	10·6	26	3·24	3·53
6	Horizontals and self-steaming B.W. gas	392	126	..	10·6	26	2·75	2·69
	Extra 68 therms obtained for (per therm)	..	..	..	..	..	2·15	1·97
7	C.W.G. plant, self-steaming ..	400	236 (1 ton coke, 59 gals. oil)	..	7	..	2·87	2·75
8	C.W.G. plant, self-steaming ..	500	336 (1 ton coke, 135 gals. oil)	..	16	..	3·25	3·17
	Extra 100 therms obtained for (per therm)	..	..	..	..	..	4·10	4·15
9	London Companies' horizontals ..	535	70·6	10·8	9·6	26	2·05	2·35
10	Verticals	470	82	9·4	14·0	28	1·83	2·11
11	Verticals	450	85·7	10·0	17·2	30·2	1·58	1·85
12	Tully, complete gasification ..	340	180 (1 ton coal, 3¼ cwt. coke and breeze)	..	12	..	2·13	2·15
13	Robinson, complete gasification ..	380	170 (1 ton coal + fuel for steam)	..	12	..	2·23	2·25
14	Parker, low temperature	700	39·6 (1 ton coal, 3½ cwt. coke and breeze)	13·9	18·6	1·78 gallons spirit	1·41	2·06
15	Maclaurin, low temperature ..	250	68·5 (1 ton coal, 1 cwt. breeze)	11·0	15·6	17	1·42	1·77
16	Nielsen, low temperature	425	94·5 (1 ton coal, 1½ cwt. breeze)	7·5	20·0	..	1·61	1·81
17	Marshall-Easton, low temperature	480 to 380	67·2 to 124·0	10·0 to 5·6	18·0	28	1·15 to 1·35	1·49

Lines 1, 2, 5, 6, relate to Dr. Parker's figures on Lanarkshire washed nuts.
Lines 7 and 8 relate to Dr. Parker's figures.
Lines 3 and 4 relate to Fuel Research Board results adapted (Mitchell Main nuts).
Lines 9 and 12 are from published results.
Line 14 is taken from Fuel Research Board results.
Lines 15 to 17 are taken from results published by inventors.

		Column A. *s. d.*	Column B. *s. d.*		Column A. *s. d.*	Column B. *s. d.*
For lines 1 to 13	Coal per ton	32 0	32 0	Tar per gallon	0 3½	0 3
	Coke per ton	30 0	27 6	S/A per lb. profit	0 0½	0 0½
For lines 14 to 17	Coal per ton	32 0	32 0	Tar per gallon	0 5	0 4½
	Semi-coke per ton ..	35 0	32 6	S/A per lb. profit	0 0½	0 0½

at no increase in the labour costs, and very little for repairs. It is possible, therefore, that the maximum make of therms per retort in the house may be more economical than maximum therms per ton.

The efficiency of carbonising plants in general must be judged entirely on their individual merits according to known results and the proposals put forward by competing contractors; but it may be of interest to investigate the financial results of the methods of carbonising summarised in Dr. Parker's paper to the North British Association of Gas Managers previously referred to, as well as other systems. In Table II two bases are taken, the second showing a lower return for residuals.

The first eight items in this table should be used for making comparisons only within limits. The Lanarkshire washed nuts produce only 9,670 cub. ft. of 600 B.Th.U. gas, or 58 therms per ton, with 8·1 cwt. of coke for sale, when carbonised in horizontal retorts. It would appear that either this is an unsuitable coal for horizontals or that the horizontal retorts were not in a good condition, for when carbonised in vertical retorts 9·4 cwt. of coke were produced, with 67 therms of gas. The unreliability of the thermal balance from the financial point of view, even when dealing with the same system and plant, is shown in comparing lines 1 and 2. The thermal balances of these two are almost equal, whereas line 2 produces gas about 30 per cent. cheaper than line 1, due to the therms in the gas being of more value than the therms in the coke. It will be seen that the extra therms produced by steaming are much cheaper than either obtaining additional therms in a blue water gas plant or by carburetting; in fact, the steaming of vertical retorts probably represents the cheapest method at present known of obtaining increased output. The figures are on the assumption that the coke from the steamed verticals is of the same value per ton as unsteamed. The results for low-temperature systems show-up very favourably on the prices given; and if the yields can be guaranteed, coupled with a market value of 5s. per ton in excess of coke for the solid fuel, there are decided attractions in most systems.

The Capacity of the Distribution System.—Whatever may be the differences of opinion regarding methods of manufacture, there is no doubt that the high-grade gas is favoured by the distribution engineer, for the following reasons: (1) Less pressure is required to deliver thermal units in a highly condensed form, due to the less volume to be dealt with. Alternatively the same works pressure gives a better pressure to the consumer. (2) The lower volume is associated with a lower specific gravity. (3) The higher grade keeps the mains and services more free from corrosion, and therefore their carrying capacity is maintained. (4) The higher grade is usually associated with a higher saturation point, and naphthalene is less troublesome. There is no doubt, therefore, that economically the higher grade scores on all points.

Latest Development in Manufacturing Processes.—During the past few years two methods of carbonising have been developed for town gas manufacture—complete gasification and low-temperature carbonising. There is no doubt that complete gasification has come to stay. It is flexible, and the two systems previously referred to can be utilised to produce gas of considerable variation. In general, it may be expected that any process giving a large thermal yield per ton of coal handled will produce low operating and repairs costs per therm, and this is intensified where there is no solid by-product to handle.

Low-temperature carbonisation has yet to prove its right as an accepted business proposition in gas-works, but there have been substantial improvements in recent years. It is obvious that the success of any system must depend primarily on the willingness of the public to purchase the resultant fuel at a price which compensates for the lower thermal production; and, secondly, the capital cost and working expenses must be reduced. The former of these secondary factors is more difficult of realisation than the latter, having regard to the large amount of coal to be handled and distilled in relation to the thermal yield. Contrasting extreme methods, complete gasification offers low capital with gas yields amounting to 140 to 180 therms per ton. Low temperature pure and simple is the reverse, as the constructional parts must deal with a heavy throughput with a yield of only 40 to 60 therms per ton, with no compensating speed of distillation.

For this reason the trend of modern invention is in the direction of admixtures with producer and water gas; and it would appear that success is likely to be achieved on these lines, using the heat as far as possible for internal carbonisation. If the public can be converted to the advantages of smokeless fuel, there will still remain the competition between gas coke at (say) 8s. per ton less than coal, and low-temperature coke up to 5s. per ton more than coal. Experience has taught low-temperature advocates that there is no advantage to be gained by carbonising poor coals with high ash content.

Table III below shows the results given, and the financial return, when taking coal at 32s. per ton, the solid fuel at 35s. per ton, oils at 5d. per gallon after deducting the recovery costs, and sulphate at £4. 13s. 4d. per ton profit. The capital is calculated from the only figures available on a basis of 240 maximum days per year; and the author has made certain adjustments, in order to draw a comparison between the four systems and the gasworks method, where usually the "coke for sale" is after providing fuel for distillation, as well as works boilers, &c. It is difficult to get exact comparisons, as the coals treated are not all the same.

TABLE III.

—	Maclaurin.	Nielsen.	Parker (Coalite).	Marshall-Easton.
Capital cost per ton of coal per annum	34s.	19s. 6d.	37s.	18s.
Do. per therm per annum	5·96d.	2·48d.	11·21d.	3·21d.
Gas per ton	27,400 × 250	22,250 × 425	5,600 × 705	14,000 × 480
Therms per ton ..	68·5	94·5	39·6	67·2
Net coal cost per therm	1·42d.	1·61d.	1·41d.	1·15d.
Labour and supervision per therm	0·27d.	about 0·25d.	—	0·25d.
Repairs per therm ..	0·36d.	about 0·30d.	—	0·25d.

Operating Costs.—Under this heading are included wages, fuel or power costs, and repairs. All are important; and it is possible for an increase in wages to counterbalance a saving in net coals when comparing two systems, and frequently a particular plant may be chosen on account of low wages and repairs together. Dealing with wages first, it is difficult to lay down any hard and fast rule, as the scale of operation differs in almost every case, and the cost is dependent on the full or partial employment of the plant. Minor variations in the value of coal gas cannot be said to influence the wages costs per therm. Vertical retorts are cheaper to operate per therm than horizontals. The additional therms obtained from steaming are gained at less cost per therm than the straight coal gas, thus reducing the cost of the whole; and this would apply even with steam generated in an outside plant. Water gas is cheaper (even per therm) than coal gas of the same size output, if each plant is operated to the same proportion of its maximum production. The additional therms obtained by carburetting are obtained for practically no increase in wages, thus reducing the overall wages cost per therm. Wages in complete gasification systems should be the lowest of all, if the plant is properly designed and in proper working order. A decrease in the carbonising period for horizontal retorts will lead to increased wages per therm, unless there is sufficient elasticity in the arrangement of shifts, or the increase in therms per retort compensates for the more frequent charging. As a general rule, the less the amount of solid fuel handled per therm, the lower should be the expenditure on wages.

It is difficult to get actual wages comparisons, owing to the different methods of allocation in existence. Taking "Field's Analysis" for 1923 the lowest is 0·306*d.* per therm for Belfast, and the highest 1·019*d.* per therm for Oldham. It is probable that items are omitted in Belfast which are included in Oldham. With regard to the comparative costs of wages for coal gas and carburetted water gas, in the same publication the figure for water gas amounts to 0·5*d.* per therm, and coal gas amounts to 0·6*d.* per therm or thereabouts. The following are recently published figures for carbonising wages per therm made, though they may not all be compiled on the same basis:—

	d.
Verticals at Glasgow	0·38
Verticals at Glasgow	0·39
Verticals at Coventry	0·27
Horizontals at Coventry	0·41
Tully gas at Halifax	0·55
Horizontals at South Metropolitan, 1924	0·52
Horizontals at Newcastle	0·40
Robinson's plant at Harrogate	0·20
Horizontals at Harrogate	0·40
Low temperature (Maclaurin's estimate)	0·27
Eastbourne, horizontals—machine-charged	0·58
Welwyn, hand-charged retorts	0·99
Pinner, hand-charged retorts	0·90
Pinner, water gas lightly carburetted	0·75

The above figures are comparable when dealing with the same works, but, as before mentioned, the expenditure in the printed accounts conveys no evidence that one method of carbonising or one quality of gas offers overwhelming advantages in wages expenditure. In the case of water gas, the wages per therm decrease as the amount of carburetting increases; further, the wages increase as the plant is used at a lower percentage of its maximum. In machine charging the therms made per charge are of primary importance. Hence the reduction in wages which can be effected by changing from 8-hour to 12-hour charges while retaining 8-hour shifts. It often happens, however, that the throughput is slightly reduced by this change; but in considering wages only, the reduced number of charges should result in a saving. Another objection to the 4-hour break between shifts is the difficulty in regulating the quality and the additional work put on parts of the plant during the concentrated period of rapid gas production. With regard to all the overhead charges, such as salaries, collection, and management and administration, the costs under these headings would not be affected by the grade of gas. The number of therms sold is for all practical purposes independent of the grade; and no change can affect the costs per therm, unless the calorific value were put so high or so low as to cause numerous complaints, which would result in additional clerical work and greatly increased inspection charges. There is as much danger in going too high as too low; but the responsible official is not likely, except in emergencies, to go to such extremes as would bring trouble of this nature.

In considering repairs, the term must be used in the widest sense, *i.e.*, the estimate must be based on the total provision which is to be allowed for maintenance, repair, and ultimate renewal of the plant in either its original form or replacement in a modern form. An examination of the repair and maintenance costs of many undertakings will show that approximately one-half of the total is expenditure on wages paid to the employees of the undertaking in question; and there are certain items which would be independent of the quality of the gas manufactured, so that the cost per therm would simply be a fixed annual charge divided by the number of therms sold. With regard to the maintenance, repairs, and renewals of the exhausters, washing plant, purifiers, and gasholders, it is clear that a low grade of gas would necessitate a larger piece of plant in each case; and, consequently, the fuel, oil, paint, and general attention would be more than in the case of a higher grade, and the cost of repairs and renewals would be higher. Consequently the higher the quality the lower the repairs and maintenance costs would be.

The estimates for the corresponding expenses for the carbonising plant and coal and coke-handling machinery is not such a simple matter, however, though considerable assistance is given by the experience of the past, and certain basic considerations. For instance, for coal handling, the cheapest plant per therm would be that handling the least coal, and therefore the system producing the lowest cost in respect of this item would be that producing the maximum number of therms per ton. The same would apply to the coke plant. In both, however, certain fixed charges must be met, and the time element must be a factor, as a plant handling no coal or coke would require a certain amount of maintenance. Further, a large plant on a reduced tonnage would not show the same saving as a new plant of smaller size. In the case of charging machinery there are certain maintenance charges which are fixed amounts, and other variable charges dependent on the type of machine, and speed and amount of coal dealt with; but probably the heaviest part is that caused by the wear of the chain and portions which are put into the retort. Consequently the lowest cost of upkeep is that which entails the minimum number of charges put in the retorts for each 100 therms manufactured.

With regard to the retorts proper, higher heats entail higher repair charges; but the additional therms obtained by increased throughput and higher thermal make per ton may well compensate for this. The throughput of coal is dependent substantially on combustion-chamber temperatures; and in conjunction with this one must consider whether the charge can be adequately burnt-off in less time than that actually employed. In other words, high thermal yield cannot always be maintained in addition to high throughput. A more important factor in retort repairs, however, is the variation in the heat of the retort caused by the introduction of cold coal, coupled with the damage due to the insertion of the chain and pusher head. Consequently the least expensive method for each retort is that which gives the greatest number of therms per charge. In comparing types of carbonising plant, the repairs of the simpler types of plant will obviously be less than those more complicated. Therefore the repairs to a water gas plant or a complete gasification plant should be lower per therm than other systems, for two reasons: (1) Less costly on account of the actual material in them. (2) More therms produced per ton of coal or coke.

The size of the unit is of importance, for it is costly to throw out a unit forming a substantial proportion of the daily make for a repair in a limited part of the setting. The effect of the annual charge for sinking fund based on a useful life of (say) 35 years would not be important

HEAT TREATMENT LABORATORY; THE ROYAL TECHNICAL COLLEGE, GLASGOW.

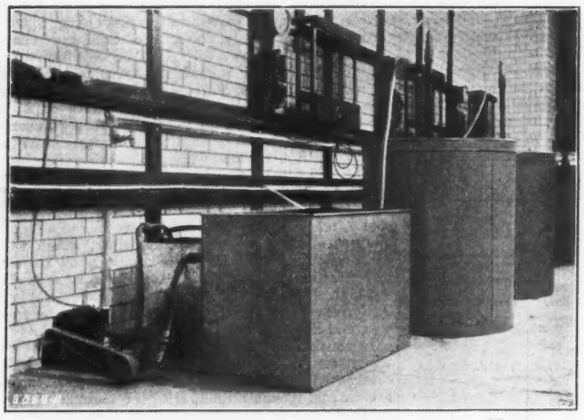

FIG. 1. OIL QUENCHING TANK AND RESISTANCE FURNACES.

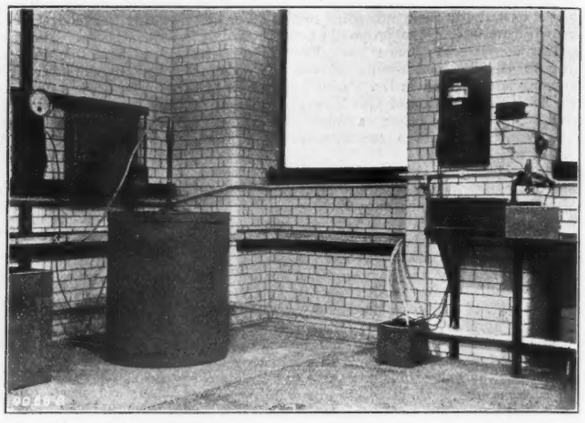

FIG. 2. PYROMETER, SELECTOR SWITCH AND CONNECTIONS TO THE FURNACES.

when divided over the gas made annually. The difference between the cheapest and the dearest plant would not be likely to exceed 0·05*d.* per therm manufactured. In dealing with existing plants, the rival claims of thermal make per ton, per retort per day, and per charge have to be considered. Table IV, below, is based on a make of 10,000 therms per day, with 23 in. by 16 in. retorts 20 ft. long, or (say) 18 ft. run effectively charged. The tons of coal used may be said fairly to represent the "net coal factor," the retorts at work the "capital factor," and the retorts charged per day the "wages factor."

TABLE IV.

—	64 Therms per Ton.			68 Therms per Ton.			72 Therms per Ton.		
	8 Hours.	10 Hours.	12 Hours.	8 Hours.	10 Hours.	12 Hours.	8 Hours.	10 Hours.	12 Hours.
Tons of coal used (net coal factor)	156	156	156	147	147	147	139	139	139
Thickness of charge (excluding scurf) ..	7·6 in.	9·1 in.	10·7 in.	7·6 in.	9·1 in.	10·7 in.	7·6 in.	9·1 in.	10·7 in.
Percentage of sectional area filled (excluding scurf)	56	67	77	56	67	77	56	67	77
Retorts at work (capital factor)	104	108	113	98	102	107	93	97	101
Retorts charged per day (wages factor) ..	312	259	226	294	245	214	279	233	202
Thermal make per retort	96	92·5	88·5	102	98	93	108	103	99
Thermal make per charge	32	39·5	44·2	34	41	46·5	36	43	49·5

The table is based on 10 cwt. for 8-hour charges, 12 cwt. for 10-hour charges, and 13½ cwt. for 12-hour charges.

With regard to mains and services, it has been shown earlier that either larger mains must be used with a lower calorific value, or, alternatively, increased initial pressures. The capital costs of mains or operating costs of boosting must be taken into account, but only the repairs are for the moment under consideration. There is little doubt that the low grade causes increased running costs for maintenance and renewal of services; and the chief expense would arise in relaying services in a larger diameter, and replacing all services on the district on a larger scale when the first replacement is complete. The same would apply to mains. Therefore, even if the distribution system is capable of dealing with the lower quality, the system loses a potential margin for increase which it would possess if the calorific value were kept at a higher figure. There is no doubt, therefore, that the district repairs, as well as the over-all distribution costs, would be higher with low-grade gas.

Capital Costs and Rate of Interest on Money.—This factor is of great importance when new plant is under consideration, as money is usually dear at the time the required plant is most expensive. The thermal output must be considered in conjunction with the annual interest and sinking fund (or interest and depreciation) charges based on the estimated useful life of the plant; and in making the choice the necessary expenditure to other parts of the plant (if any) must be considered. The plant should be capable of renewal in comparatively small sections, avoiding the renewal of substantial parts of the work, as the wear may be confined to small portions. The size of the unit must be considered, as a section used at a small proportion of its output is costly. The capital and sinking fund charges should, therefore, be assessed on the estimated requirements, and not on the maximum capacity. Table V, below, gives approximate costs of a plant making 10,000 therms per day, including coal stores, coke and coal handling plant, generating plant, and preliminary condensation. The useful life is taken at 33 years (1 per cent. sinking fund on 6 per cent. basis), and the interest at 6 per cent.

TABLE V.

Type of Plant.	Cost.	Interest and Sinking Fund per Annum at 7 per cent.	Interest and Sinking Fund per Therm Made.
	£	£	*d.*
Horizontal retorts	40,000	2,800	0·28
Vertical retorts	50,000	3,500	0·35
Carburetted water-gas plant	26,000	1,820	0·18
Tully plant	30,500	2,135	0·21
Robinson plant	42,500	2,977	0·30
Parker low-temperature ..	112,000	7,840	0·78
Maclaurin low-temperature	60,000	4,200	0·42
Nielsen low-temperature ..	25,000	1,750	0·175
Marshall - Easton low-temperature	33,000	2,310	0·23

If the nature of the plant necessitates a shorter working life, then the sinking fund must be adjusted accordingly. The annual make is taken at 240 maximum days = 2,400,000 therms.

From the above figures it is clear that the lower-grade gas is considerably cheaper with respect to capital, and this is to be expected where the process consists in the more or less complete gasification of the fuel. In addition to occasions when new plant is required, a change of calorific value may involve capital expenditure, or alternatively result in postponing it. Owing to the trend of markets a lower calorific value may result in a great saving in manufacturing costs, but entail heavy capital expenditure in mains, services, boosting plant, or even storage plant. Therefore, the economic effect of this expenditure must be balanced against the savings.

THE HEAT TREATMENT OF STEELS.

IN no type of technical industry has more progress been made in recent years than in the provision of alloy steels which have been heat treated to obtain the qualities demanded by the user. The value of this to an engineer cannot be gainsaid, but how common it is that the only attention the subject receives in the course of work given to engineering students in the colleges consists in attendance at a short course of lectures. That this is unsatisfactory must be owned, and it is therefore of interest to note what is being done to remedy the defect in one of the leading institutions devoted to technical education. To give a real insight into the questions involved in metallurgical work which are of importance to engineers, Professor J. H. Andrew, of The Royal Technical College, Glasgow, has started a special course of 100 lectures, with practical demonstrations, and has equipped a new laboratory for the use of the students in studying the effects of heat treatment. The laboratory, two views of which are shown in the figures above, is equipped with four wire-wound electrical resistance furnaces with effective temperature controls, and located beside them are both oil-quenching and water-quenching tanks.

The resistance furnaces have quartz tubes, 9 in. diameter and 2 ft. long, on which the wire is wound to obtain an even heating to within 3 in. of either end. These tubes are set in a packing of kieselguhr contained in a sheet-iron casing of about 2½ ft. diameter. To prevent air currents, the bottom of each furnace is bricked up, and arrangements have been made so that the bottom can be brought up to any desired level by the introduction of additional bricks. As each of the furnaces is controlled by a separate rheostat, it constitutes an independent unit, and the current may be regulated at will to obtain a constant temperature at any value between 300 deg. C. and 950 deg. C. For the temperature indication a Siemens wall-type of pyrometer (see Fig. 2) has been installed, and it may be connected to any one of the permanent thermo-couples in the furnaces by means of a selector switch. Usually two of the furnaces will be kept at high temperatures for hardening, normalising and annealing, while the others will be devoted to work at lower temperatures involved in tempering operations.

The quenching tanks are placed between the furnaces so that no time need be lost in transferring the specimens to them while hot. For the oil tank a cooling coil with pump circulation is provided, while the water tank has water flowing through it continuously from the main supply. To obtain increased floor height around the furnaces to facilitate the removal of the specimens, platforms will be fitted beside them. A Bradshaw double-chamber furnace has also been installed for the purpose of hardening high-speed steel, the forced draught for which is obtained by the use of a Roots blower. It will be appreciated that the whole equipment, which, while eminently suited to the work undertaken in a college, is also such as could be installed in any works where an economical and efficient means of heat treatment is desired.

In the work of the course, the students will receive a preliminary training in the preparation of specimens and their examination by the microscope. Then they will proceed to the heat treatment work and deal with a representative selection of carbon and alloy steels and also test their physical properties in the mechanical engineering laboratory.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

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The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

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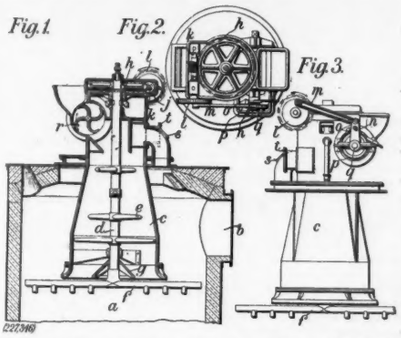
GAS ENGINES, HOLDERS, PRODUCERS, &c.

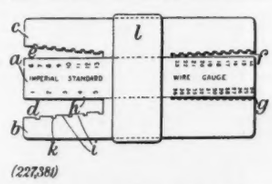
227,348. G. H. Bentley, Westminster, London, and E. G. Appleby, Westminster, London. Gas Producers. (3 *Figs.*) May 22, 1924.—This invention relates to gas producers having a main gas generating chamber combined with a distillation chamber, an agitator in the distillation chamber, and an agitator in the gas generating chamber. *a* is a gas generating chamber having an outlet *b*, and *c* is a distillation chamber arranged in the upper part of the chamber *a*. In the chamber *c* is a shaft *d* carrying agitators *e*, *e*, *e* located in the chamber *c*, and at the end of the shaft *d* is an agitator *f* in the chamber *a*. On the shaft *d* is also a bell *g*. Secured to the upper end of the shaft *d* is a wormwheel *h* gearing with a worm *j* on a shaft *k*, having at its end a toothed wheel *l* through which the mechanism is driven.



To the toothed wheel *l* is pivoted a link *m* which is also pivoted to a rocking lever *n* carrying a pawl *o*. The latter engages ratchet teeth on a wheel *p* on a shaft *q*, which carries a rotary feed valve *r*. By this means the rate of rotation of the feed valve *r* varies with the rate of rotation of the agitator shaft *d*. The distillation chamber *c* is provided with two outlets *s* and *t*, regulated by dampers (not shown), the outlet *s* leading back to the gas generator *a* and the outlet *t* to a condensing apparatus of usual construction. The fuel from the distillation chamber *c* is fed past the bell *g* to the gas generator *a* at such a speed that the level of the fuel in the gas-generating chamber is kept at the proper height. The top of the charge is maintained in the level condition by the agitator *f*. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

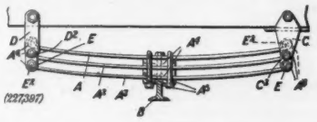
227,381. James Chesterman and Co., Limited, Sheffield, and A. Hill, Sheffield. Wire Gauge. (4 *Figs.*) August 5, 1924.—The invention relates to wire limit gauges of the kind comprising an oblong steel plate that is provided with a slot or slit which is of tapering width and has marks at intervals along the slot indicating the numbers or sizes of wires which, when introduced into the slot, would just fill the width of the slot at those points. The improved gauge has a body consisting of two or more plates arranged lengthwise side by side and clamped together. These parts are so shaped that one or more slots are formed between



the adjacent parts, the edge of a part bounding one side of a slot being flat-surfaced, while the edge of the adjacent part bounding the other side of the slot is stepped and notched along its length in a manner to provide a series of gauging points, the steps being spaced apart with a notch between each pair of steps, each step having a face opposed to and parallel with the flat-surfaced side of the slot, the distances or widths between successive steps and the flat surface are successively decreased in accordance with the graduated scale of sizes of the Imperial Standard, Birmingham Wire, sheet metal or other standard gauge. The gauge illustrated comprises three plate parts *a*, *b*, *c* arranged side by side. The plate *a* is of rectangular shape, while plates *b* and *c* would be rectangular were it not that portions of those plates have been removed to form in conjunction with plate *a* four slots *d*, *e*, *f* and *g*, one side of each slot being flat-surfaced as at *h* and the opposite side stepped and notched as described above. The steps along the sides of the slots are denoted by *i* and form stops or gauging points, the steps being separated one from another by the notches *k*. The gauging points on one face of plate *a* may be marked with wire sizes according to the Imperial Standard wire gauge, and on the reverse face with decimal equivalents, but sizes according to any other standard gauge may be marked thereon. After the plates *b* and *c* have been stepped, notched and accurately machined, they are assembled and clamped together, as shown, by means of the clamping plate *l* which is shrunk on or otherwise secured thereto. (*Sealed.*)

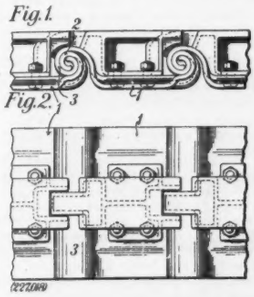
MOTOR ROAD VEHICLES.

227,397. J. Parsons, Coventry. Laminated Springs. (3 *Figs.*) October 2, 1924.—The invention relates to laminated springs of the kind in which all the leaves are independent and spaced from one another from one extreme end of the spring to the other, and at one point are rigidly clamped, spaced apart, to an attachment. According to the invention, three or more leaves are employed and one or both ends of all the leaves have a pivotal or sliding connection with the load or with a load-carrying member. The leaves A, A^2 and A^3 are spaced apart at the centre by means of spacing blocks A^4, and clamps A^5 are employed to secure the spring to the axle B. The leaves may be all alike or varied as desired, each terminating in an eye A^6 at each end so that each leaf corresponds to the main leaf of an ordinary laminated spring. The eye at one end of the central leaf A^2 is attached to a shackle pin



C^2 on a hanger C, and the eye at the other end is attached to a shackle pin D^2 on a spring shackle D of some conventional type. Upon each of these shackle pins C^2, D^2 is pivoted a pair of links E, and to these links the eyes A^6 at the ends of the other leaves A, A3 are pivotally attached, as by means of pins E^2 corresponding to the shackle pins C^2 and D^2, and the spacing is preferably such that all the leaves A, A^2 and A^3 are parallel or concentric with one another. By this means the leaves are completely separated, and therefore the surfaces require no lubrication. The leaves A, A^2, A^3 are thus able to move together with perfect freedom, and, as all the leaves are attached at each end to the spring shackles or hangers D and C, the spring will transmit a higher thrust and torque than a spring of the conventional type wherein only one leaf is, or perhaps two leaves are, attached at the ends. (*Sealed.*)

227,018. John Fowler and Co. (Leeds), Limited, Hunslet, Leeds, and W. J. Lewin, Hunslet, Leeds. Endless-Track Vehicles. (3 *Figs.*) March 21, 1924.—The invention relates to tracks for endless track vehicles. According to the invention, the track shoes 1 are each



provided or formed at their forward ends and also at their rear ends with a volute or spiral scroll 2, 3, respectively, the forward volute scroll 2 of each shoe being passed into convolute engagement with the rear volute scroll 3 of its preceding shoe. (*Sealed.*)

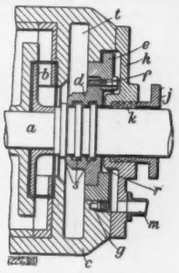
PRINTING AND ALLIED MACHINERY.

226,584. A. B. Evans, Chapeltown, Leeds. Sheet Gripping Mechanism. (4 *Figs.*) August 28, 1923.—The invention relates to sheet-fed printing machines of the kind in which the sheet is held to the sheet-carrying cylinders, chains or reciprocating carriages, by means of grippers which nip the front edge of the sheets and hold them upon gripping bars or pads fitted to and moving with the sheet-carrying cylinders, chains or reciprocating carriages. According to the invention, each individual gripper comprises two parts *a*, *c*, one, *c*, of which, forming the gripper proper, is mounted to rotate upon the gripper carrying shaft *b*, whilst the other, *a*, is secured adjustably upon the shaft and is adapted upon partial rotation of the shaft to move the gripper proper *c* from the gripping position in which it is maintained by a spring *d*, the strength of which corresponds to the pressure which the gripper is required to exert. This spring is so positioned that the force which it exerts to maintain the gripper proper in the gripping position is relaxed when the gripper proper is moved from the gripping position. The part *a* of the gripper comprises a sleeve a^1 adapted to be received upon the shaft *b* and to be secured thereto by means of a clamping screw a^2. The other part *c* comprises the gripper proper in the form of a finger c^1, the rear portion of which is bifurcated and

formed into two eyes c^2 adapted to fit upon the shaft *b* rotatably and to be positioned one on each side of the sleeve a^1. The sleeve a^1 is provided on its periphery with a projection a^3 adapted to contact with the lower face c^3 of the finger c^1 and thus to lift the finger c^1 on rotation of the shaft *b* and at the same time to limit the forward rotational movement of the part *c* with reference to the part *a*, which movement results from the action of a flat spring *d* mounted upon a boss a^4 of the part *a* by means of a screw a^5, the spring being adapted to engage at its extremity with the upper face of the finger c^1.—(*Accepted January 7, 1925.*)

PUMPS.

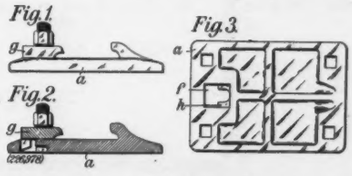
227,315. G. and J. Weir, Limited, Cathcart, Glasgow, and C. R. Lang, Cathcart, Glasgow. Packing for Shafts. (2 *Figs.*) March 22, 1924.—The invention relates to shaft packing of the type in which stuffed or contact packing is provided to augment the effectiveness of labyrinth packing. According to the invention, the labyrinth packing is adjustable, and the gland or stuffing-box of the contact packing is carried by a member which is readily removable and which, when removed, allows of access to the mechanism for adjusting the labyrinth. *c* is the pump casing and *t* is the suction chamber of the pump, this chamber being connected to the suction main. *a* is the pump shaft and *b* is the impeller mounted on this shaft. The impeller draws water from the chamber *t* and delivers it to the next stage of the pump or to the discharge main. *h* is a cover containing any usual or convenient type of stuffing-box



with stuffed packing *k* and gland bush *j*. This cover *h* may be in one piece or in halves bolted together so that it can be easily removed to permit of access to adjust the labyrinth. A leak-off pipe *m* is provided to carry away the fluid which leaks past the labyrinth packing; this prevents a rise of pressure in the chamber *r* which would cause a leakage, or increase the leakage, past the stuffed packing *k*. The shaft *a* is provided with a series of collars or rings *s* forming with the ring *d* a labyrinth. In adjusting such a packing the ring *d* is advanced until it makes contact with the collars *s*. It is then slacked back so as to give the desired small clearance and is secured in position. The packing ring *d* is secured to the flange *e* by screws *f*. This flange *e* is adjustably secured to the pump casing—say, by being screwed thereto as illustrated—and locked by the pin *g*; it is employed to adjust the labyrinth. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

226,978. E. J. Wood, Sutton Coldfield. Rail Chairs or Tie Plates. (6 *Figs.*) January 5, 1924.—The object of the invention is to provide an improved method of securing the detachable lug of a rail chair

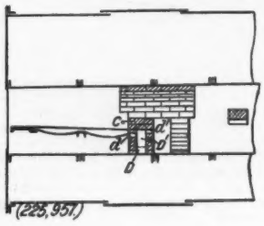


or tie plate in such a manner that the rail can be removed and replaced with a minimum amount of labour and without disturbing the position of the chairs upon the sleeper. The invention essentially consists in providing a rail chair *a* with a slot *f* of key-hole shape in plan, the wider

part of the slot being next to the edge of the chair and the narrower part being undercut on the lower surface of the chair to form a ledge *h* beneath which the head of the holding-down bolt for the detachable lug *g* is adapted to engage, the head of the bolt being adapted to be passed downwards through the under part of the slot, and the bolt being then moved along until the head engages under the ledge in the narrower part. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

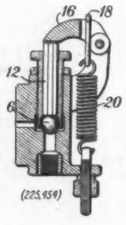
225,957. A. W. Crowther, Highgate, London. Boilers. (6 *Figs.*) September 20, 1923.—The invention relates to steam boilers with internal furnaces and flues and more particularly to the furnaces of such boilers in which an air-heating chamber is formed below the fire bridge for heating air supplied to the flue, beyond the fire bridge, for secondary combustion of the gases



passing over the fire bridge. According to the invention, the heating chamber D below the fire bridge C is provided with an inlet aperture *d* at the front and a smaller outlet aperture d^1 at the back, the chamber being divided lengthwise from front to rear by a vertically depending division wall D^1 to prevent the air from passing directly from the inlet aperture *d* to the outlet aperture d^1. (*Sealed.*)

MISCELLANEOUS.

225,454. H. S. Broom, High Wycombe, and Broom and Wade, Limited, High Wycombe. Compressors. (3 *Figs.*) April 17, 1924.—The invention relates to governors for compressors of the type comprising an adjustable spring-loaded, lever-controlled bye-pass valve with its spring load so applied that its effective restoring moment progressively decreases upon the opening of the valve and correspondingly increases on the closing of the valve, whilst the leverage controlling



the valve remains substantially constant. According to the invention, the valve is formed as a ball valve 6 and controls the movements of a sliding spindle 12 directly or through the interposition of another ball, which spindle is kept pressed on the valve 6 by the end of the spring-loaded lever 16. The lever is forked at its pivoted end, notches being provided on the forked arms for carrying a knife-edged T-member 18 connected to one end of the tension loading spring 20. (*Sealed.*)

225,351. W. Sangwin, Stockton-on-Tees. Apparatus for Drying and Heating Stone. (3 *Figs.*) November 1, 1923.—The invention relates to apparatus for drying and heating stone, slag and other materials. *a* is a vertical casing; *b*, *b* are a series of vertical plates mounted inside the casing *a* so as to leave spaces *c* between the plates *b* and the sides a^1; *d*, *d* are a series of inclined plates extending across the casing *a*, the top edges of the plates *d*, *d* being secured to the bottom edges of the plates *b*, *b*; *e*, *e* are a series of vertical plates extending across the casing *a* centrally thereof; *f*, *f* are a series of pairs of inclined plates extending across the casing *a*, each pair forming a hood, the apex of which is attached to the bottom edge of a plate *e*. All the plates *b*, *d*, *e* and *f* extend the full distance between the sides a^2 of the casing *a* and are secured thereto. The plates are placed in such relation to each other that passages *g* are formed between the plates *e*, *f* and the bottom edges of the plates *d*, whilst similar passages *h* are formed between the plates *b*, *d* and the bottom edges of the plates *f*. The bottom plates d^1 of the series *d* form a discharging hopper *j*, the mouth *k* of which is divided by a vertical plate *m* and provided with a bingate *n*. The plates *b* and *d* at the top of the dryer form, together with the top *o* of the casing *a*, a stone charging hopper *p* having a charging inlet *q*. The upper spaces c^1 are closed in by the top *o* of the casing and are provided with outlet pipes *r* which may be suitably controlled. Ports *t* are provided in the sides a^2 of the casing immediately below each end of the hoods formed by the inclined plates *f*. An air or gas supply pipe *u* is connected to one of the bottom ports *t*, whilst the remaining ports *t* are connected to each other in the manner shown by pipes *v*, an exhaust pipe *w* being connected to the unconnected top port, so that air or gas admitted through the pipe *u* will pass backwards and forwards across the dryer under the hoods *f* until it is exhausted by pipe *w*. The exhaust pipe *w* may lead to a fan 3 from which a pipe 4 is led to chambers 5 formed between the discharging hopper *j* and the bottom of the casing *a*. In use, stone is charged into the hopper *p* through

Fig.1.

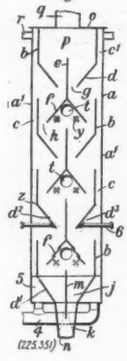
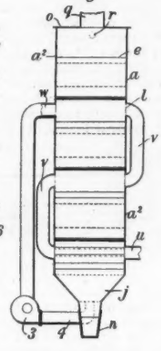
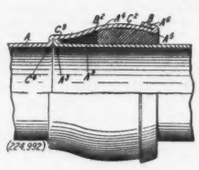


Fig.2.



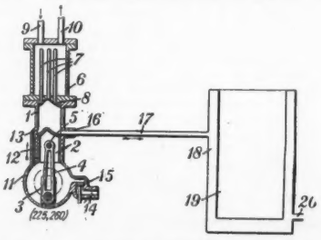
the inlet *q*, whilst hot air or gas is admitted to the dryer through pipe *u*. The stone falls by gravity from the hopper *p*, past each side of the top vertical plate *e*, through the top passages *g* on to the top plates *f*, through the top passages *h* on to the plates *d* by which it is guided through the lower passages *g*, a similar zig-zag movement of the stone being continued right down the dryer until it enters the discharging hopper *j*, from whence it is discharged through the mouth *k* by opening the bingate *n*. The vertical plates *e* prevent stone passing from one side of the dryer to the other side. The hot gases pass in zig-zag manner up the dryer by passing under the lower hood *f*, through the lower pipe *v*, under the next hood *f* and next pipe *v*, and so on, until they are exhausted by pipe *w* either to the atmosphere or as hereafter described, or for any other desired purpose. As the gases pass under the hoods they heat up the plates *f* which in turn heat and dry the stone which passes over them on its descent through the dryer. The vapour given off by the stone during drying passes under the plates *d* into the spaces *c* from whence it rises into the chamber c^1 and is exhausted therefrom by pipes *r*. The gases exhausted from the dryer may be drawn down the pipe *w* by the fan 3 and by means of the pipes 4 be injected into the chambers 5 so as to drive the vapour in the spaces *c* up into the chambers c^1 to be exhausted therefrom. (*Sealed.*)

224,992. Bromford, Limited, Aston, Birmingham, and J. Reimann, Erdington, Birmingham. Spigot and Socket Joints. (1 *Fig.*) September 12, 1923.—The invention relates to spigot and socket joints for wrought metal tubes. According to the invention, the socket is formed in an end portion of the tube which has not been reduced in manufacture to the same extent as the body of the tube. A billet is rolled as usual in a "pilger" mill to form the tube A, but the injury in making the "starts," which commonly wastes a very large amount of metal at the starting end by splitting it and causing ragged edges, is very materially lessened by not reducing the metal there to the ultimate thickness of the body part of the tube. Sufficient length of this thicker part of the billet is left to provide for the formation of the socket A^2, and the remainder is then brought down to the required thickness, and may be rolled completely to its end. The socket is formed by enlarging the internal and external diameters at the thickest end of the tube, and by producing at the same time a right-angled shoulder A^3 at the enlargement. The walls of the socket may be barrelled as at A^4 to provide a relatively wide annular space about midway along the socket, and also a narrow space around its mouth A^5. The edge of the latter is folded back closely upon itself at A^6, either internally or externally as shown, effectually reinforcing it, and, if done internally, providing a lock for the packing B in the annular space between the



socket and the spigot C^2 of the second tube. The plain spigot end of the tube A is also folded closely back upon itself externally, as at C^3, for the second tube to form, as far as possible without rounding off the end face and edges, a jointing face C^4, and thus by the provision of a joint ring (not shown) an effective joint is ensured which will prevent leakage into the annular space in the socket and avoid risk of corrosion there. In the figure the reference B indicates a lead ring and the reference B^2 is gasket, the two materials thus forming the well-known jointing means for spigotted tubes. (*Sealed.*)

225,260. A. H. Nicholson, Malvern Link. Compressed-Air Cold-Producing Apparatus. (1 *Fig.*) July 31, 1923.—The invention relates to compressed-air cold-producing apparatus for cooling-chambers and refrigerators. 1 is the cylinder, 2 the piston, 3 a crank-driven manually or by a motor, 4 the connecting-rod connected to the gudgeon pin 5. In the chamber 6 secured to the head of the cylinder are disposed tubes 7, open below and closed above, in which the air is compressed on the upward stroke of the piston. The piston is dome-shaped and the head of the cylinder is provided with a correspondingly formed recess 8. Cooling water is caused to circulate round the tubes 7; in the example illustrated entering by a pipe 9 and leaving by a pipe 10. The crank 3 rotates in the crank-case 11 and the lower part 12 of the cylinder 1 is enlarged on one side to provide a passage 13 through which air compressed in the crank-case can pass into the upper part of the cylinder. Air is supplied to the crank-case through an inlet 14 and a non-return valve 15 and cooled air passes through an outlet 16 in the cylinder 1 when this outlet is uncovered by the descent of the piston 2 to its lowest position represented in the figure. A pipe



17 is connected to the outlet 16 and leads to the jacket 18 of the refrigerating chamber 19. The cold air leaves the jacket of the refrigerating chamber by the exit 20, which may be connected to the inlet 14 to the crankcase, or, if air instead of water is used as the medium for cooling the tubes 7, may enter the chamber 6. The action is as follows:—As the piston 2 descends, it compresses the air in the crankcase; the air under pressure passes through the passage 13 and scavenges the cooled and expanded air present in the upper part of the cylinder through the outlet 16 into the jacket 18 of the refrigerating chamber 19. The scavenging action is assisted by the dome-shaped formation of the piston, which deflects the air flowing from the passage 13 towards the cylinder head. At the commencement of the upstroke of the piston the passage 13 and the outlet 16 are closed and the air above the piston is compressed and driven into the tubes 7, where it is cooled by the circulation of water or air in the chamber 6. On the downstroke of the piston the cooled air is expanded and further cooled.—(*Sealed.*)

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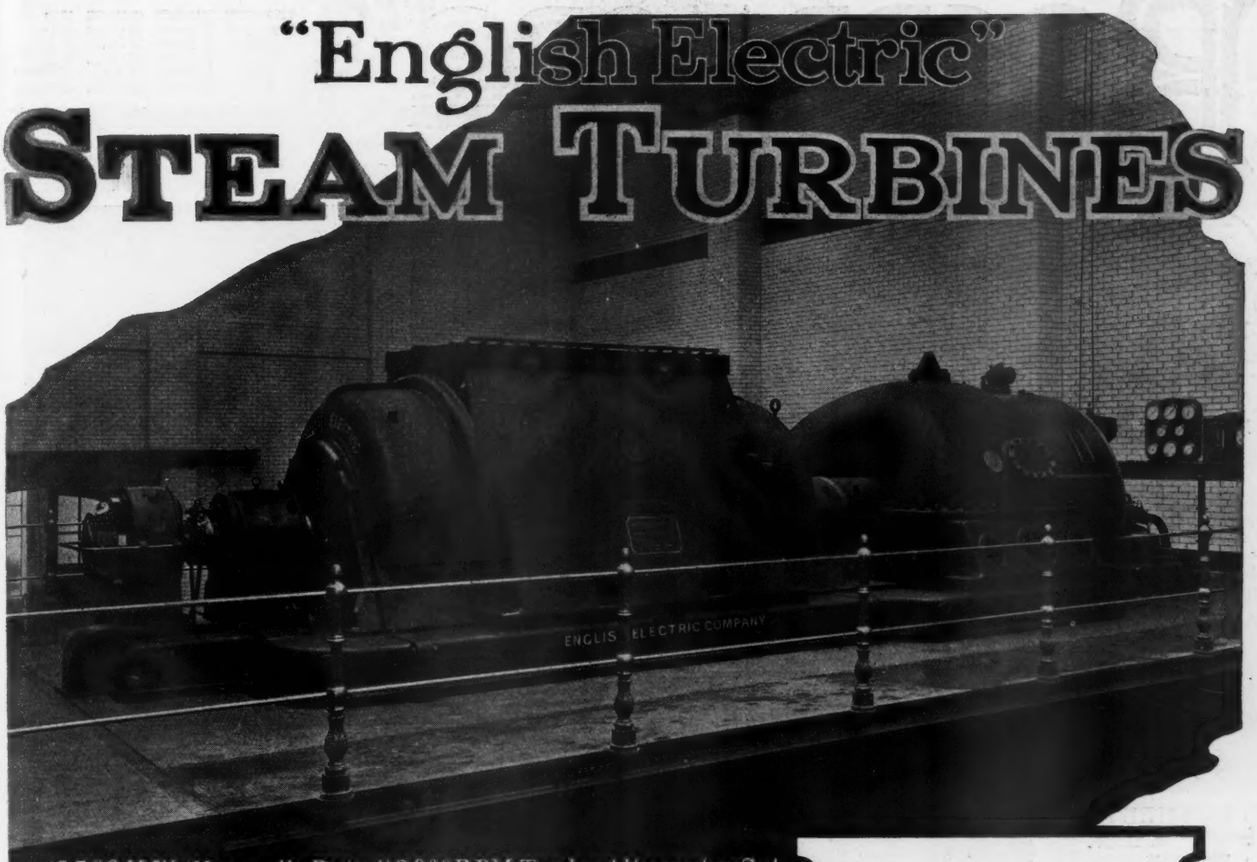

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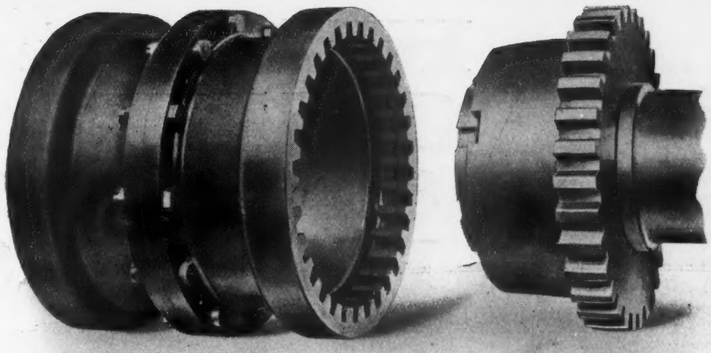

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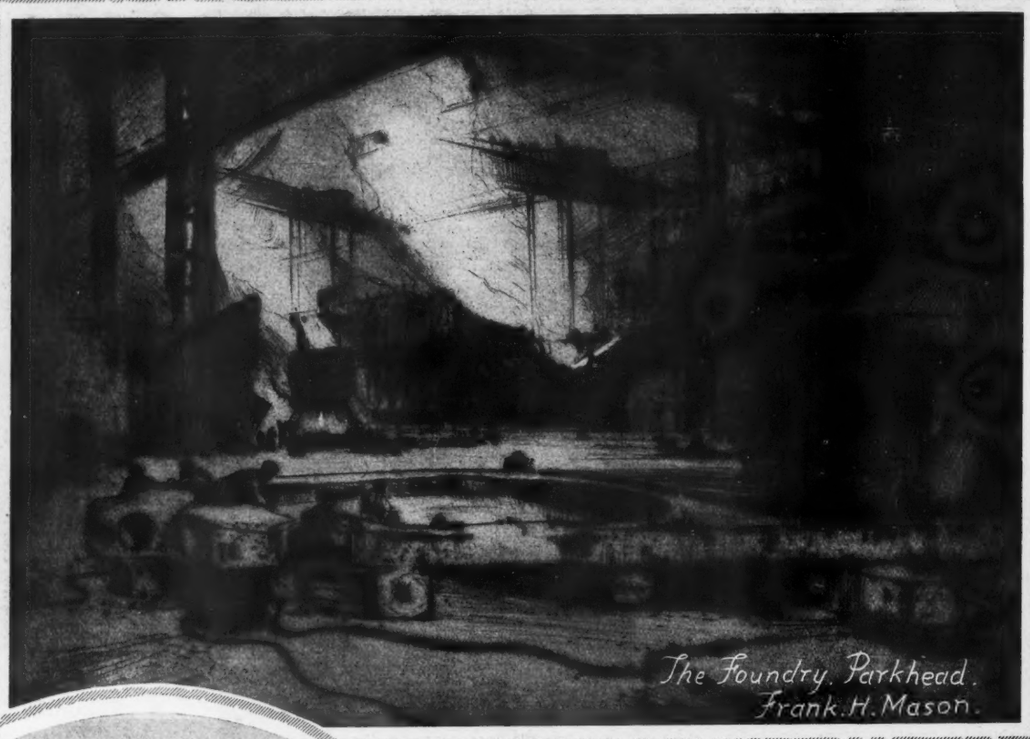

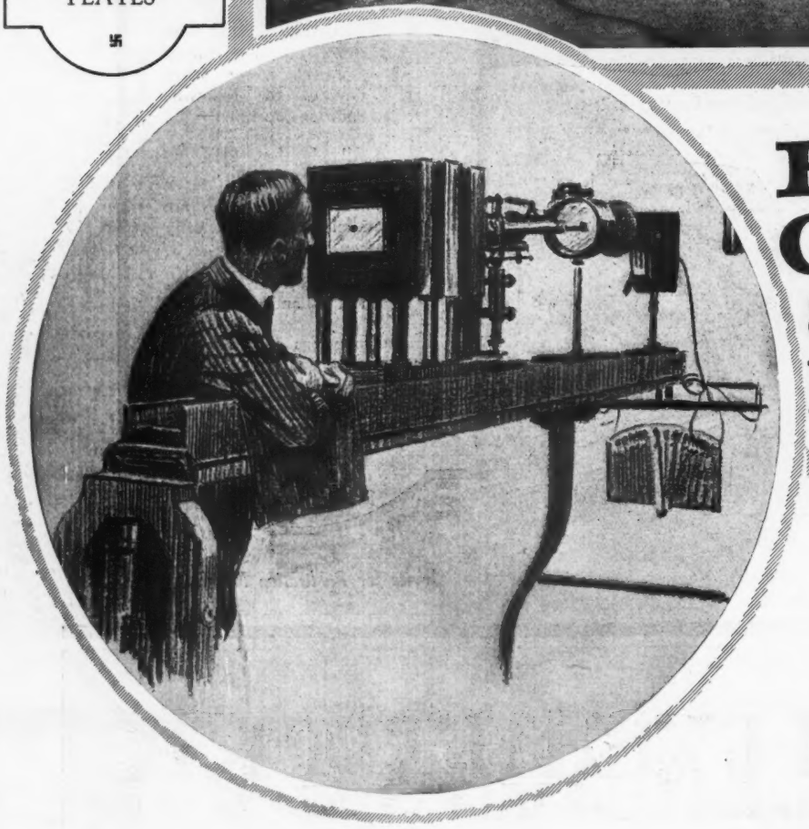

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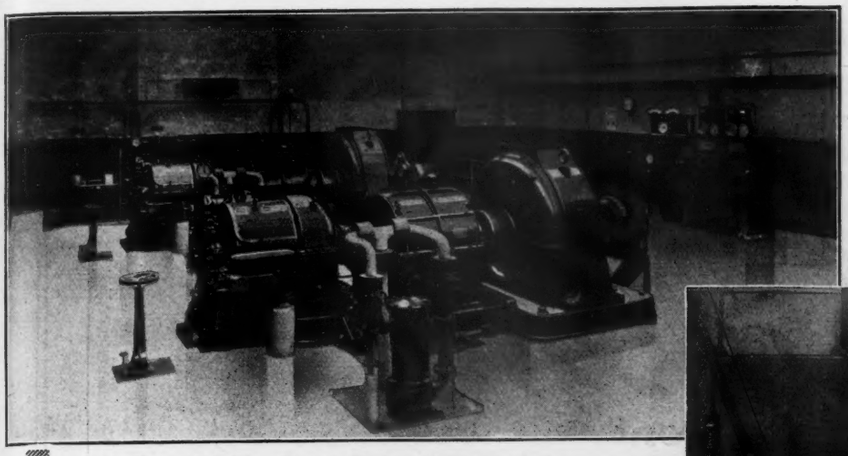

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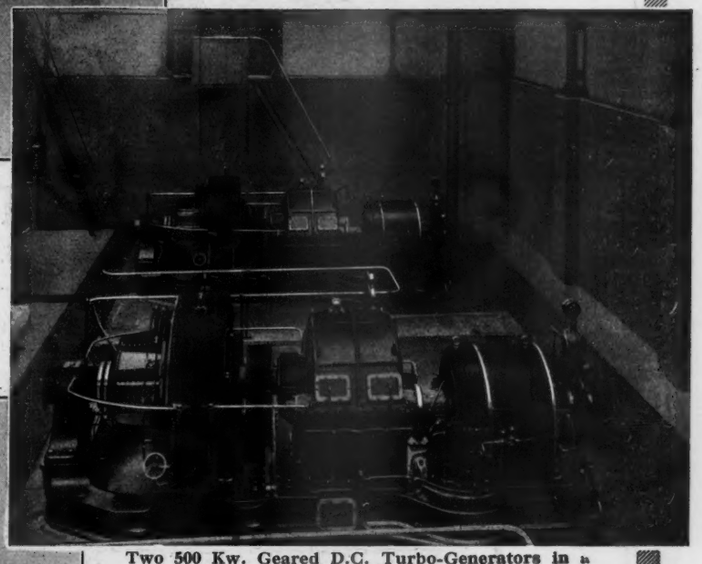

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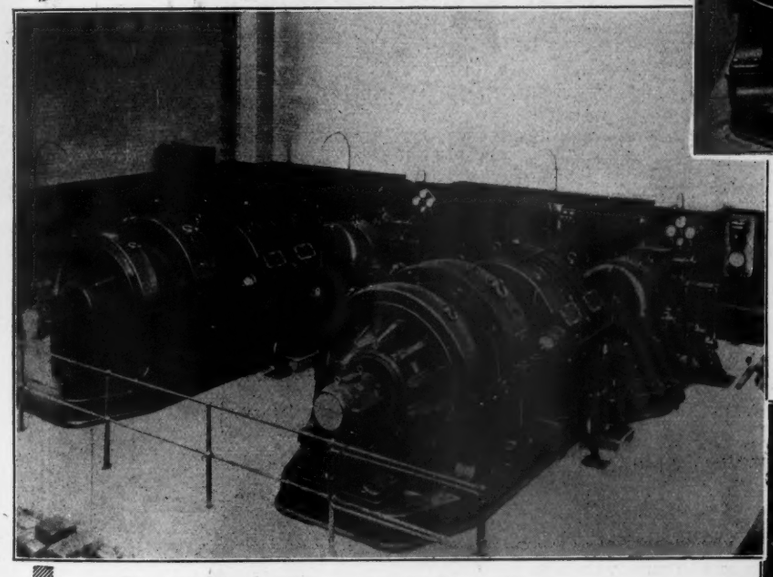

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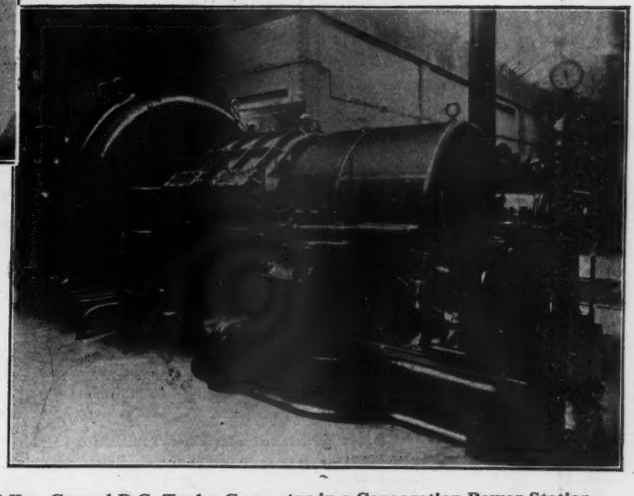

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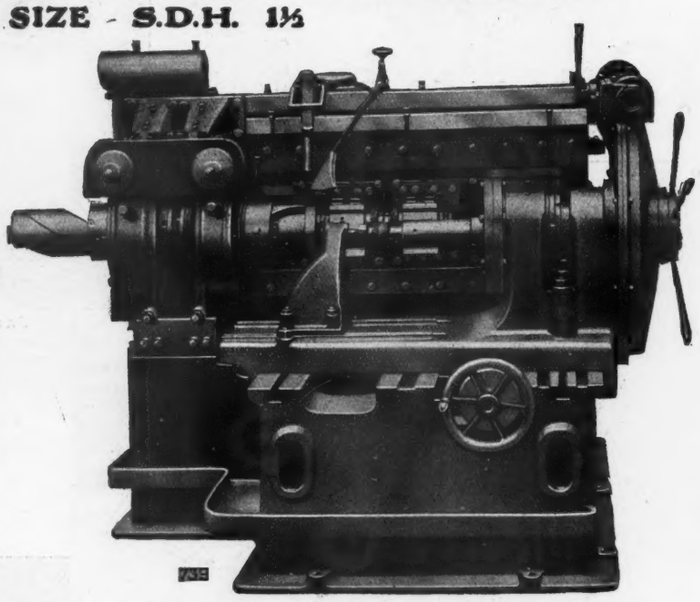

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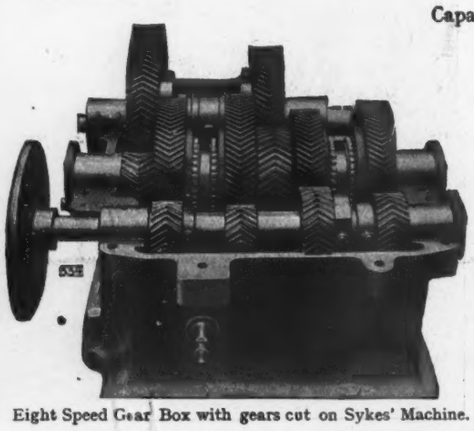

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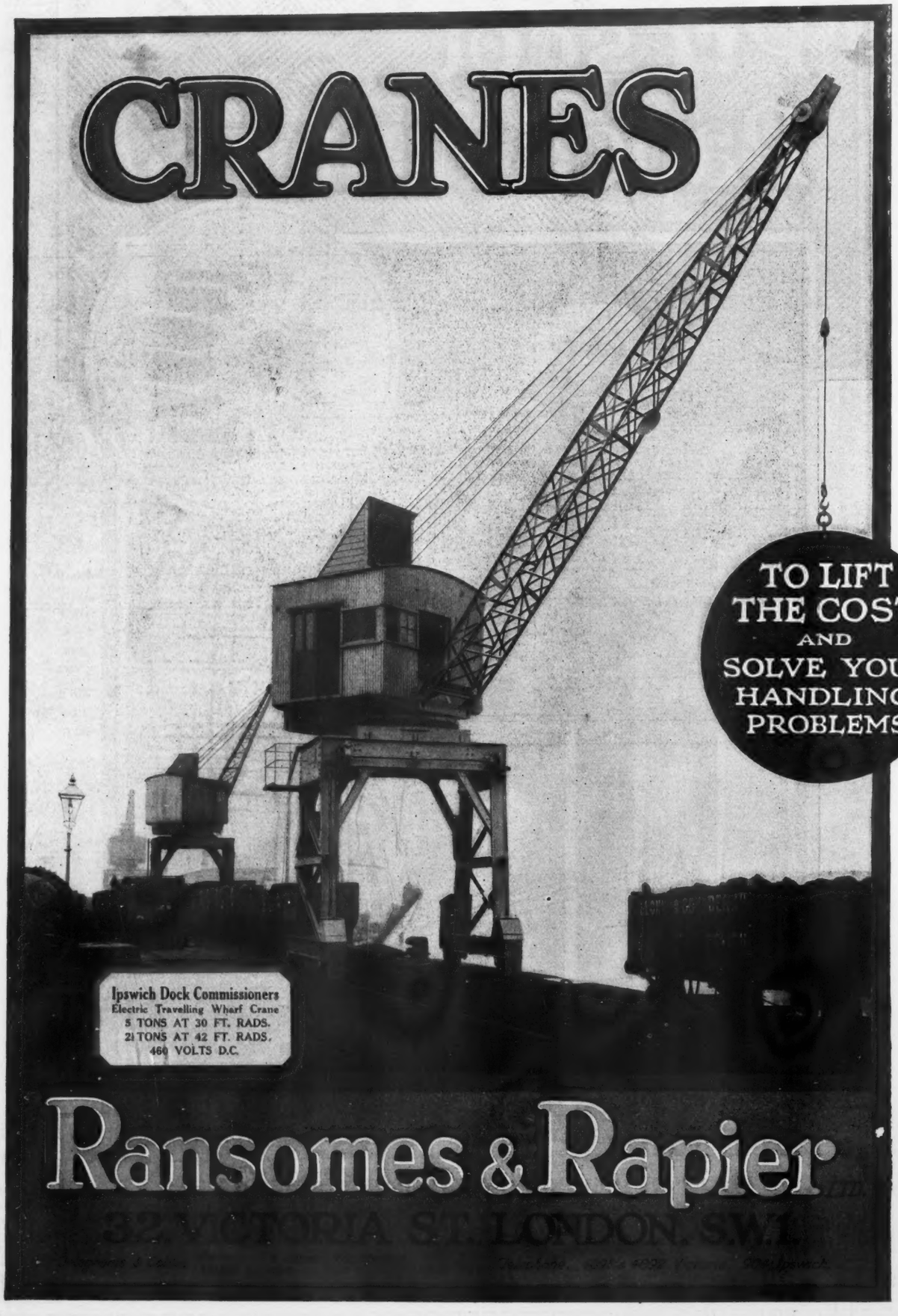
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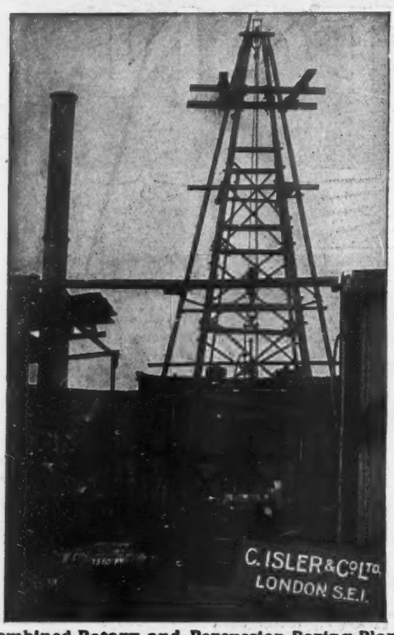

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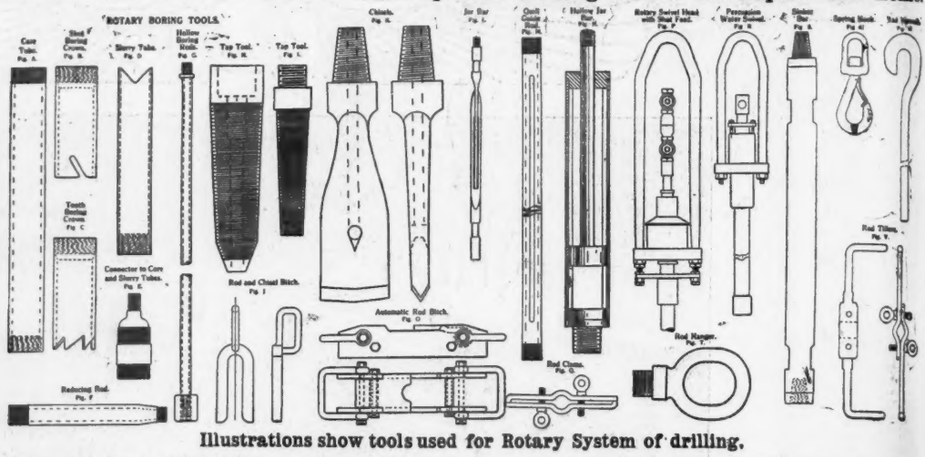

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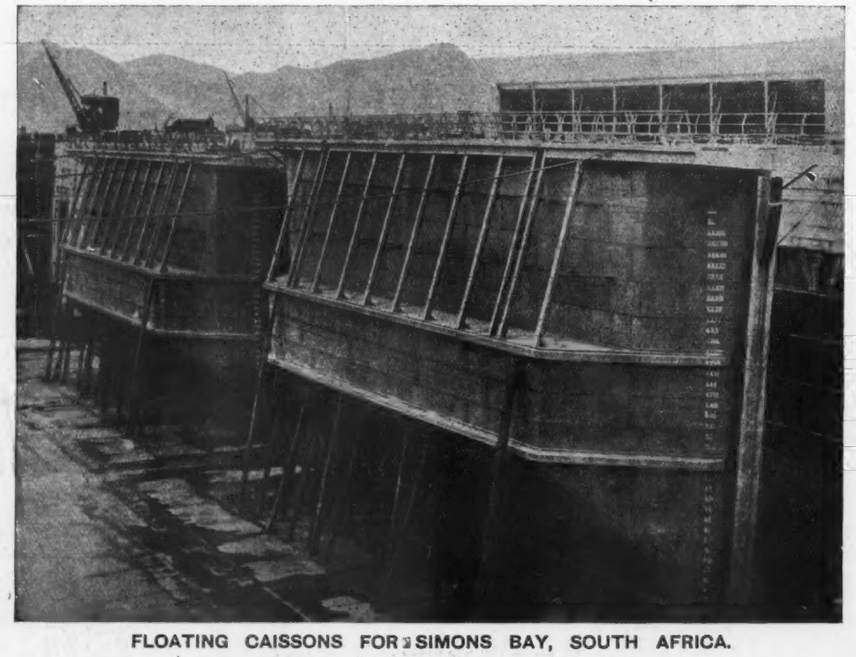

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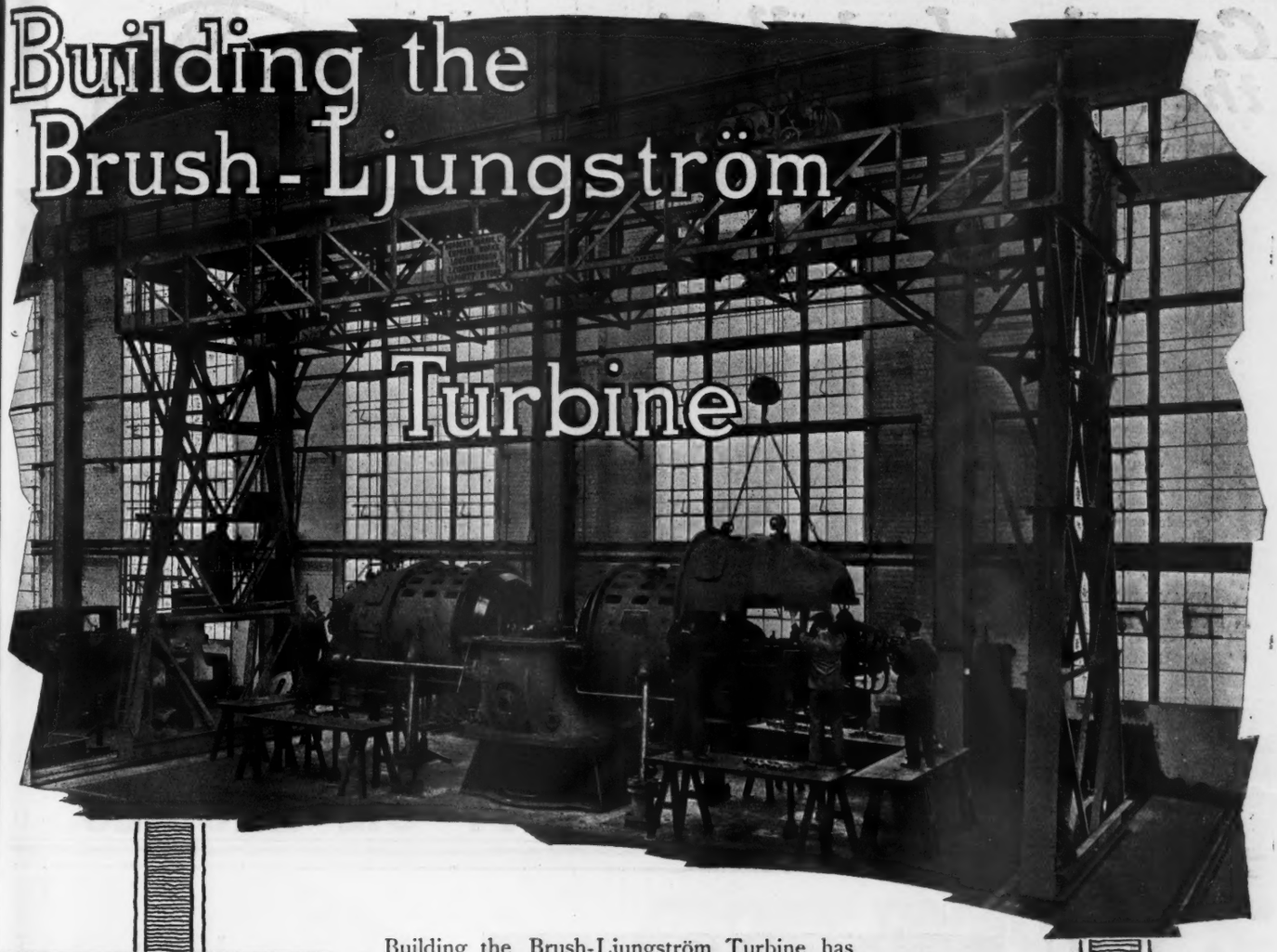

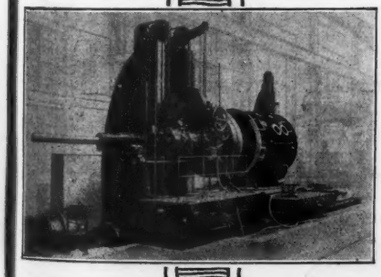

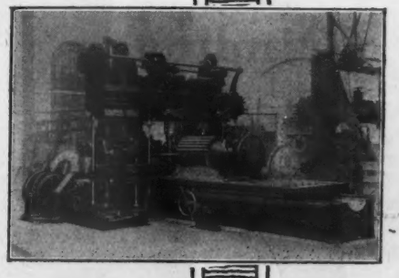

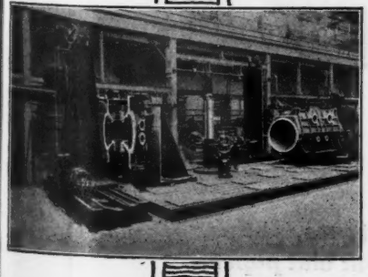

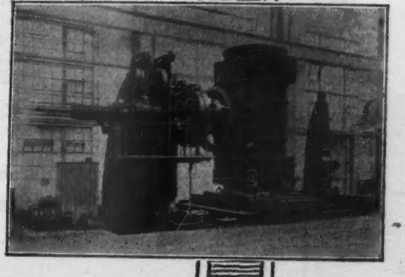

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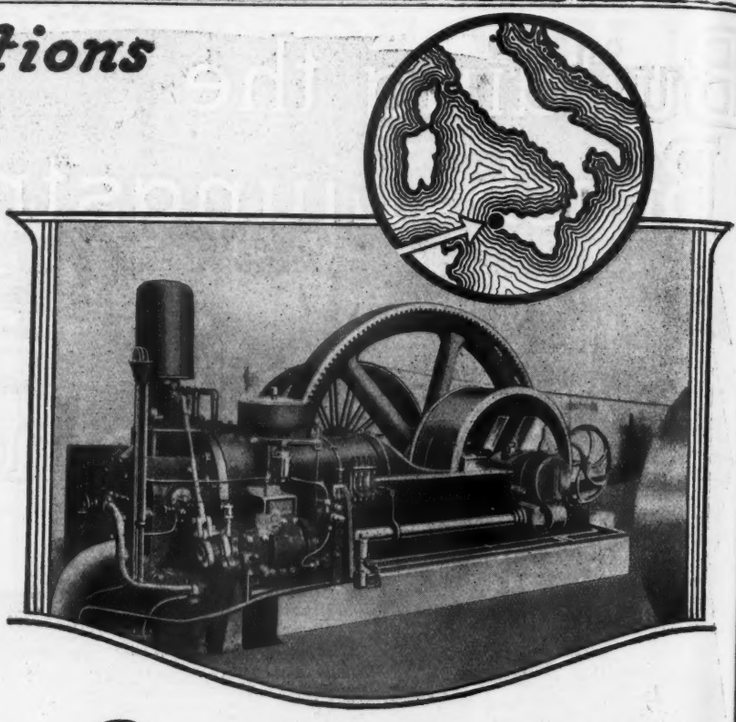

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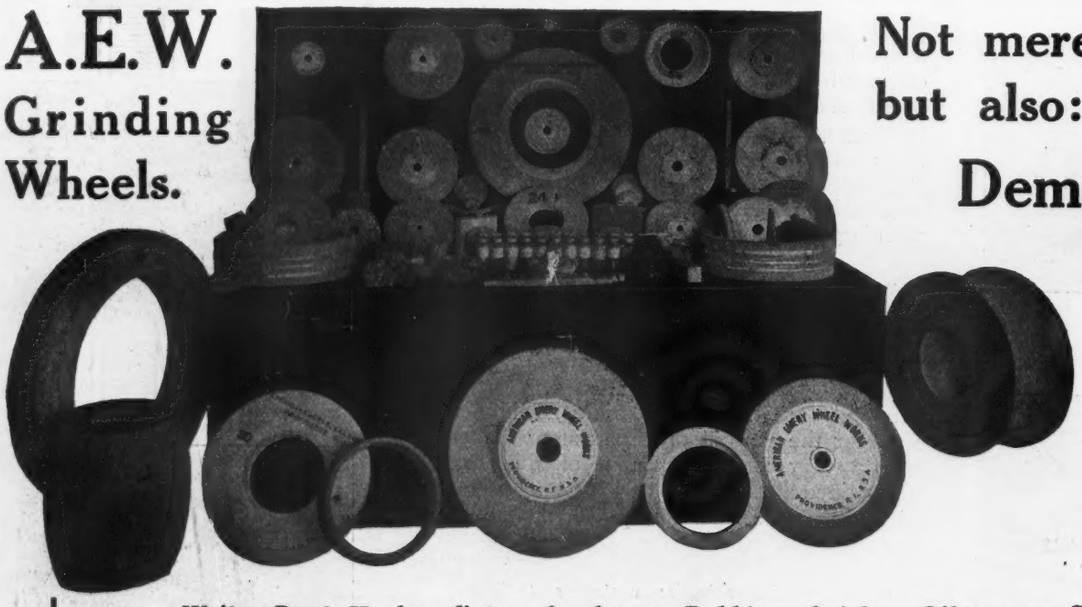

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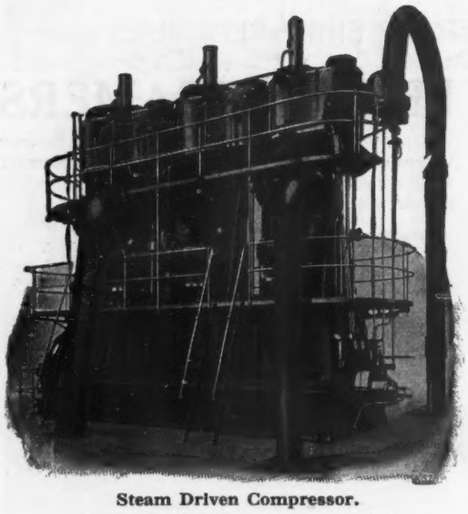
0611

"Sentinel" Air Compressors



Steam Driven Compressor.
Capacity 10,000 cu. ft. per minute.

These were the **original vertical enclosed self-lubricating machines** and were an immediate success, being accepted by the **British Admiralty** and at least 80 per cent. of the Shipbuilding Concerns in the country, solely on their own merits. Units up to 10,000 cub. ft. capacity have been supplied for general **Colliery Service,** and the present pattern still easily leads for durability, efficiency and reliability.

No. 16 Air Catalogue free on application.

"Sentinel" Ash Hoists

"Sentinel" Steering Gears

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(Valves are made at Sentinel Valve Works, Worcester).

ALLEY & MACLELLAN, LTD.,

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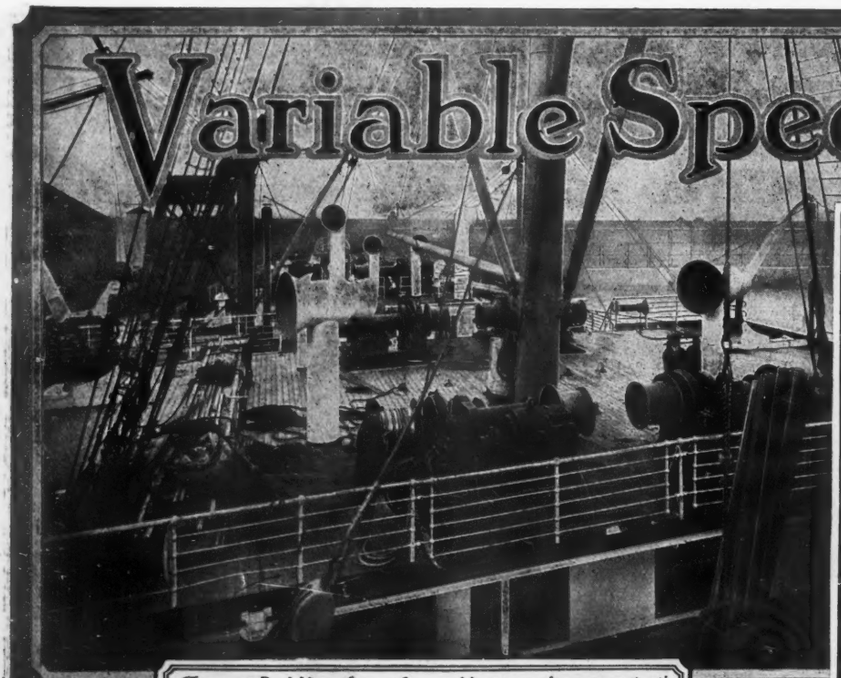
2589

Variable Speed Gear



Forward Deck View of one of several large vessels equipped with Cargo Winches, Boat Winches, Warping Winches, Capstan, Windlass and Steering Gear, all operated by Williams-Janney Hydraulic Gears

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9591

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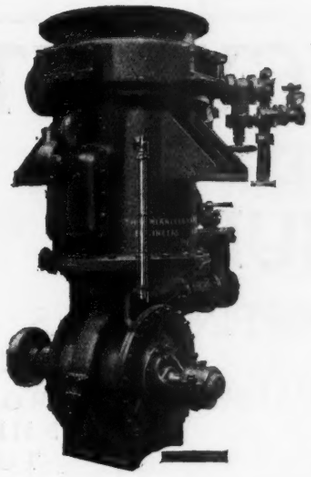
Jet Condensers



May be equipped with Rotary Air Pump or Steam Ejector Air Pump as illustrated. The spray box is specially designed to ensure complete mixture of steam with the water and offers no resistance to the flow of exhaust steam.

A special feature is the compression cone which utilises the kinetic energy of the steam and water to compress the air, thus reducing the air pump capacity.

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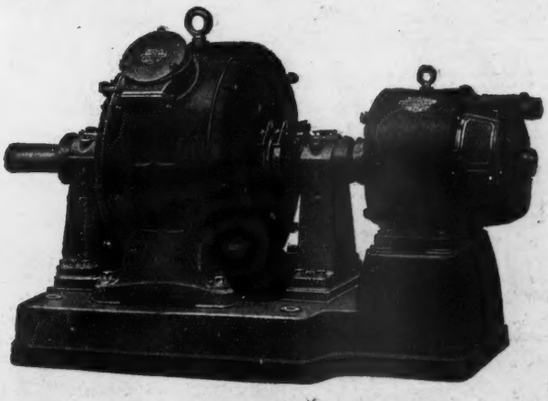

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No skilled attention is required; they start up like ordinary induction motors and pull themselves into synchronism.

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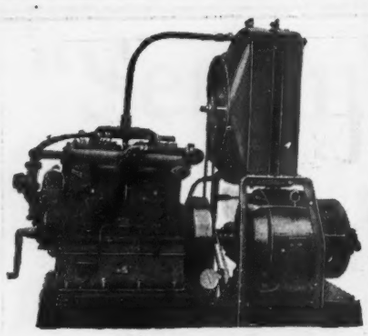

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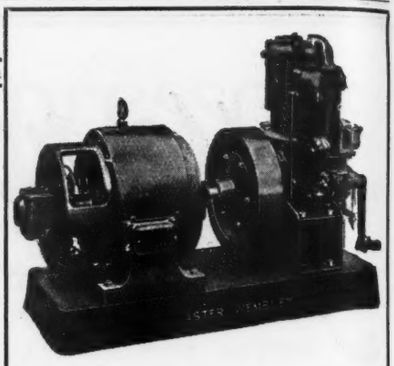

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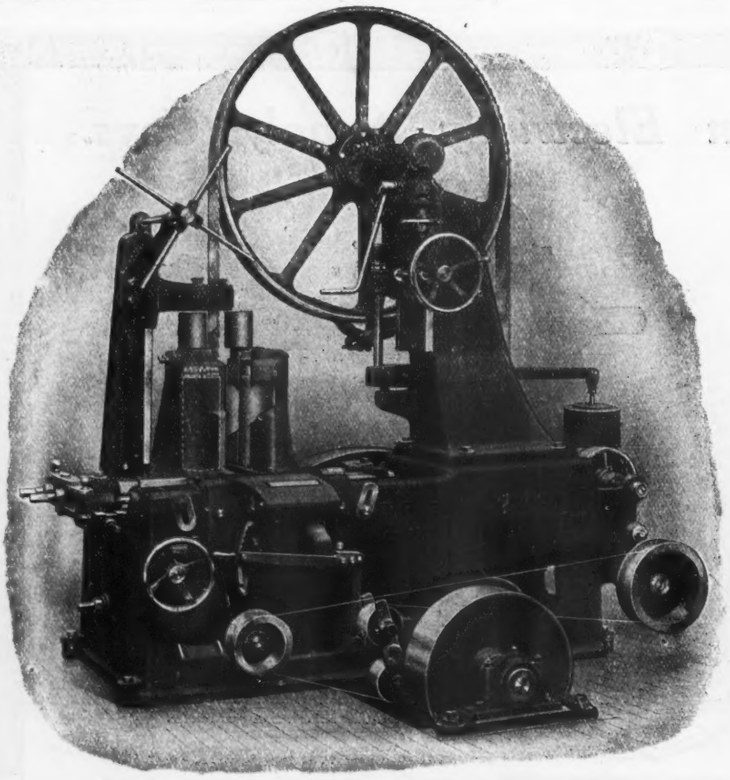

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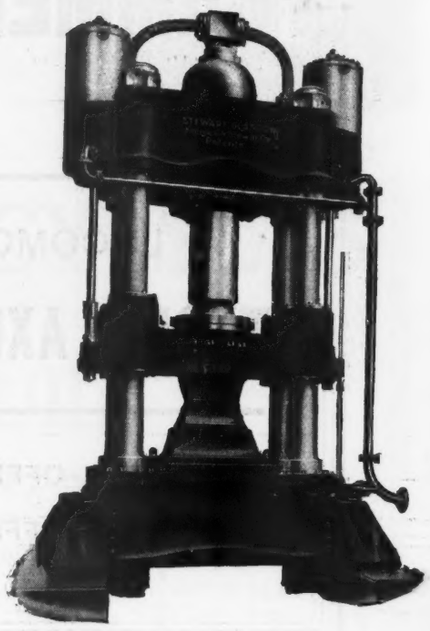

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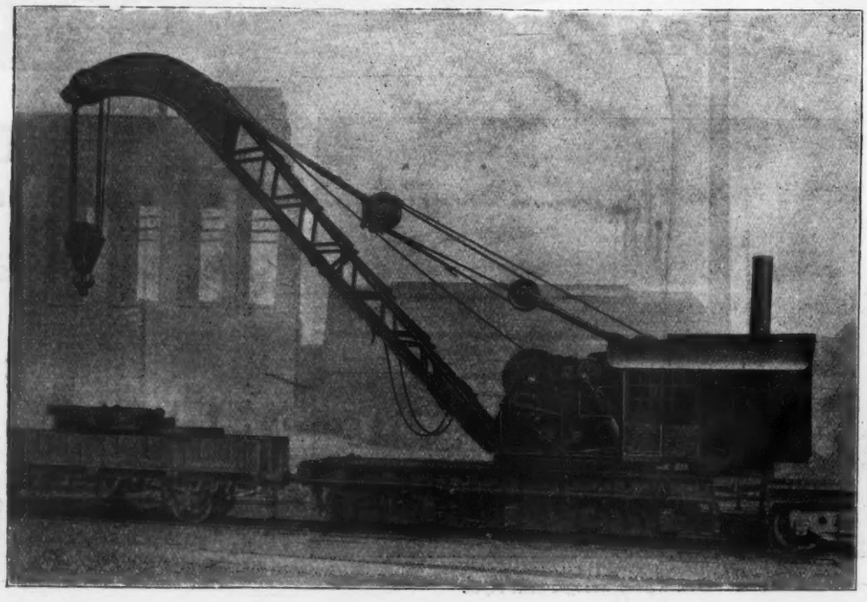

Fig. 1267.

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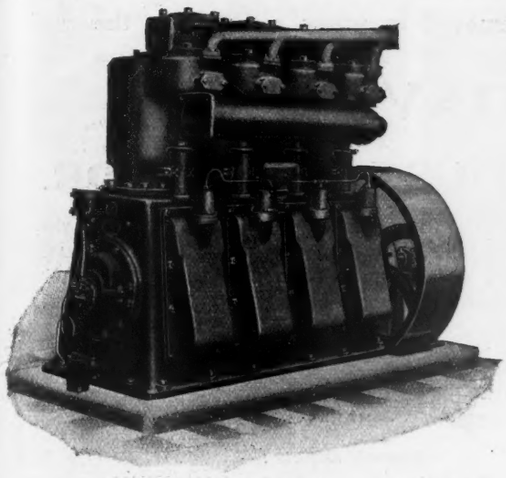

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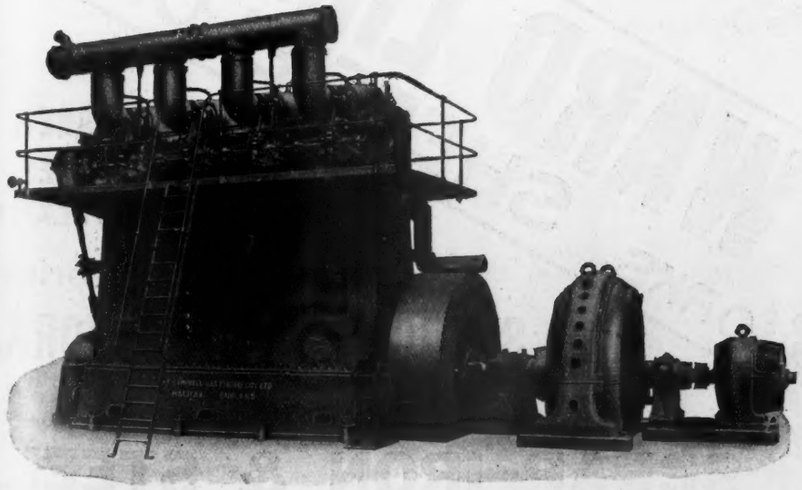

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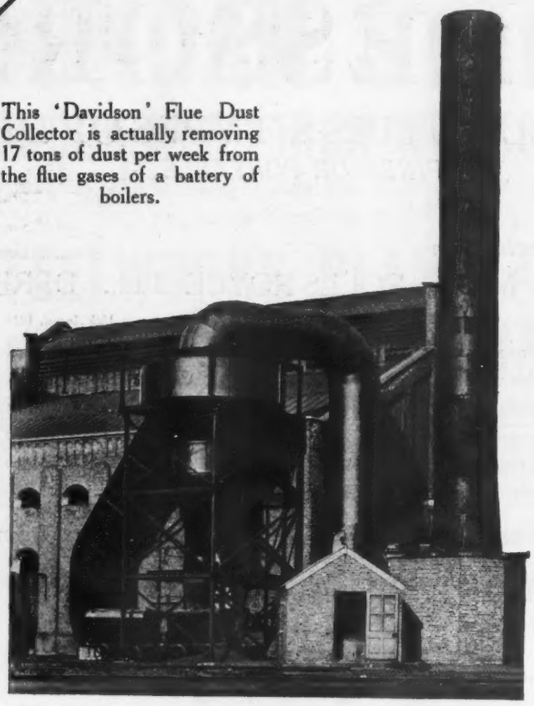

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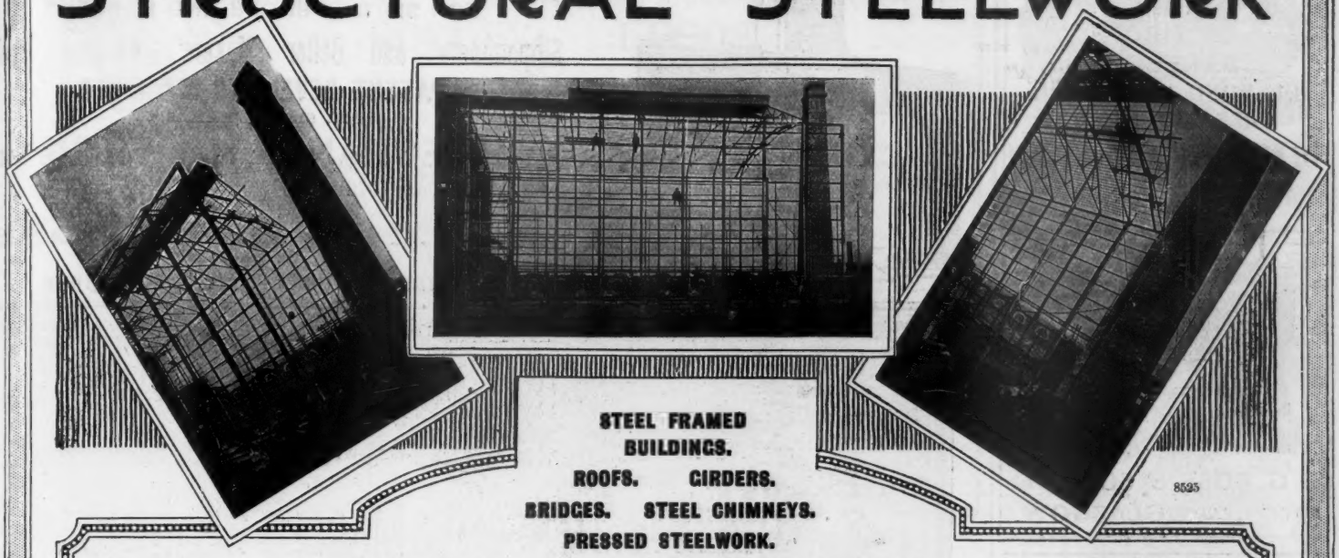

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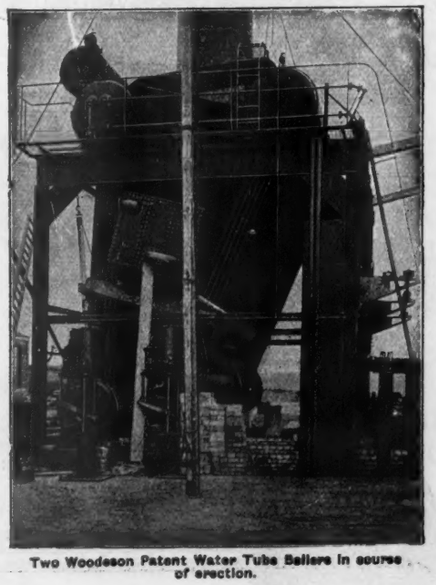

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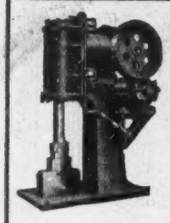

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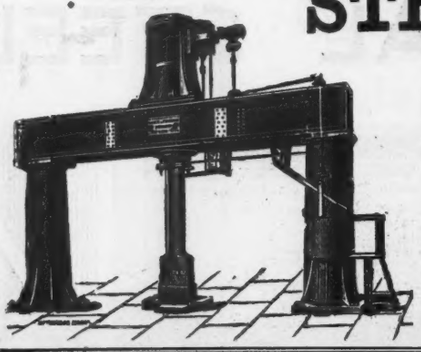

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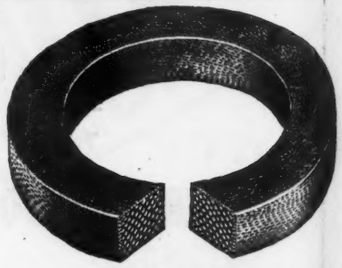

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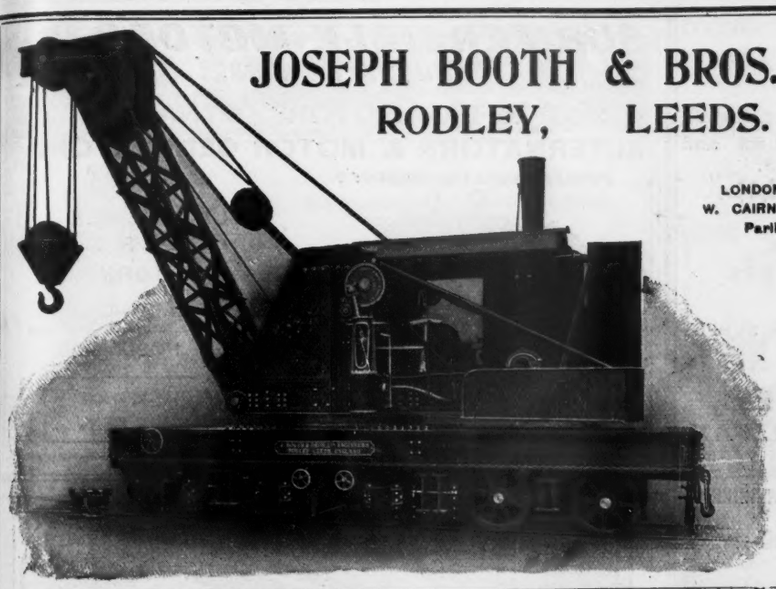

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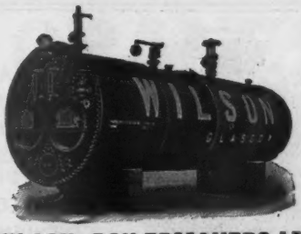

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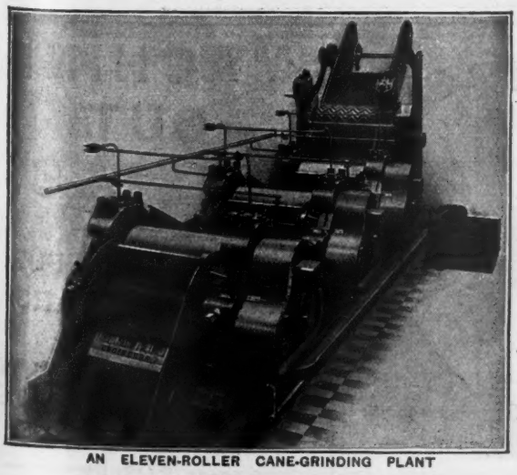

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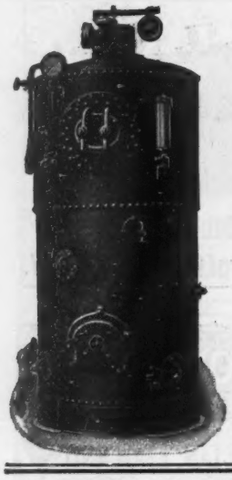

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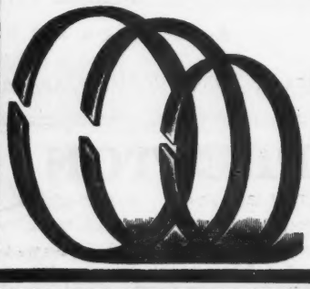

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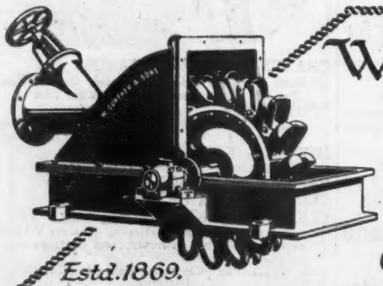

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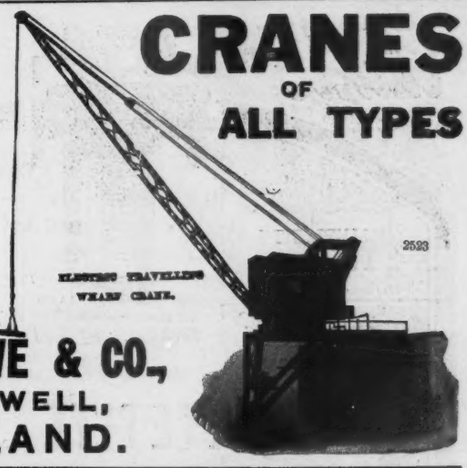

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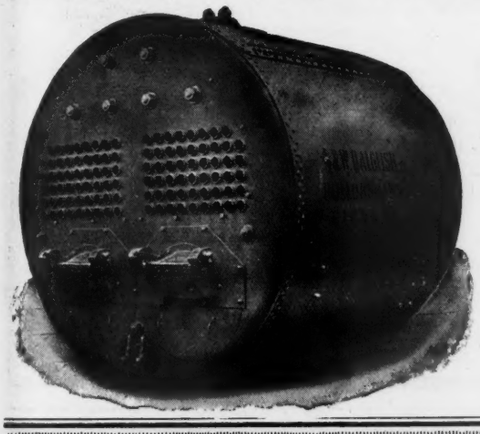

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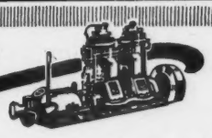

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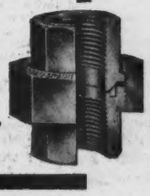

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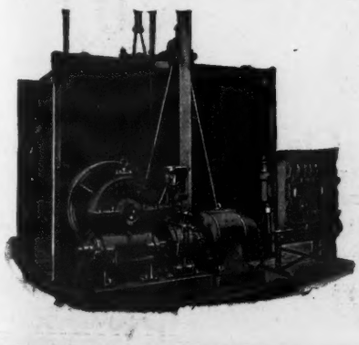

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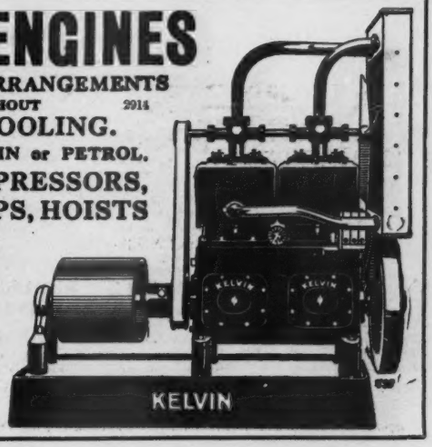

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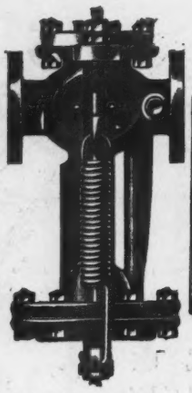

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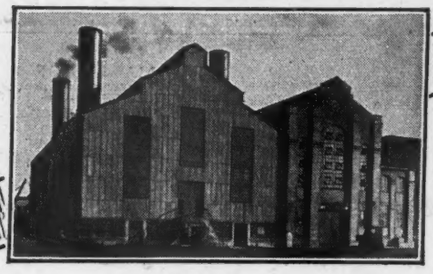

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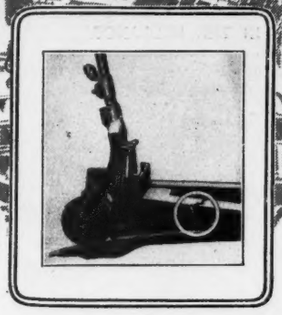

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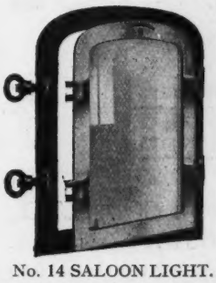

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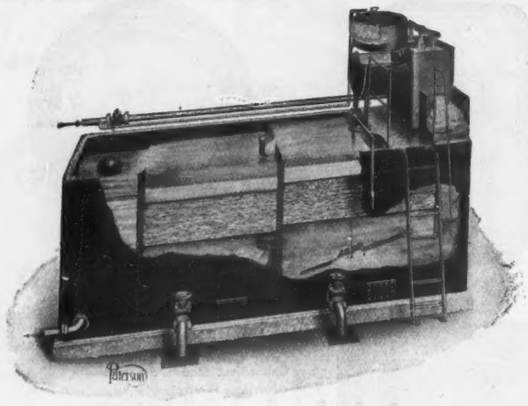

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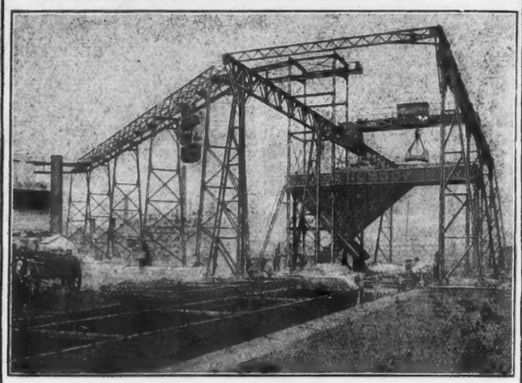

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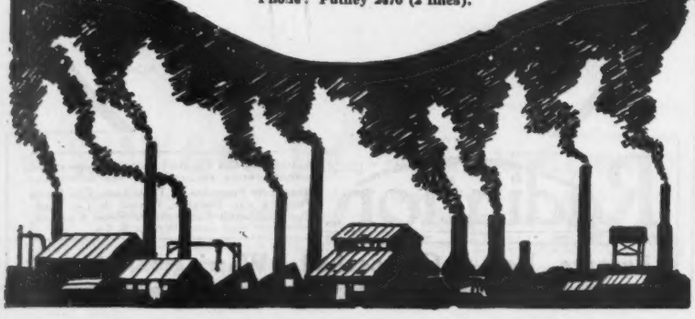

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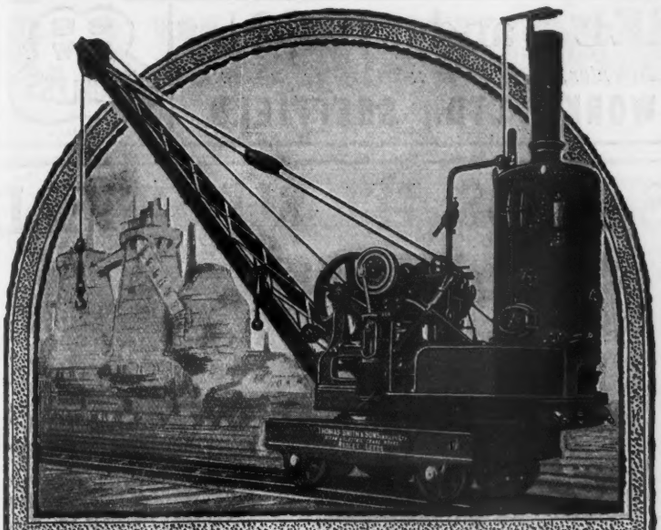

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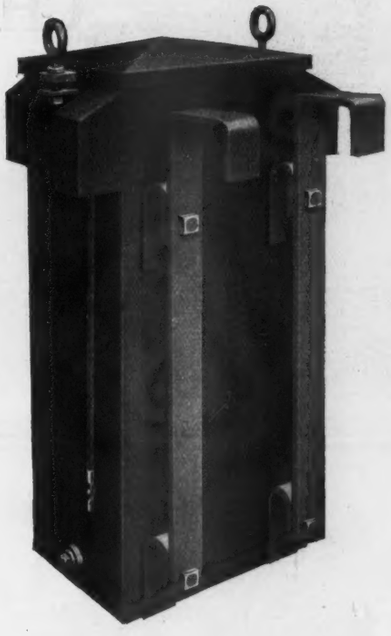

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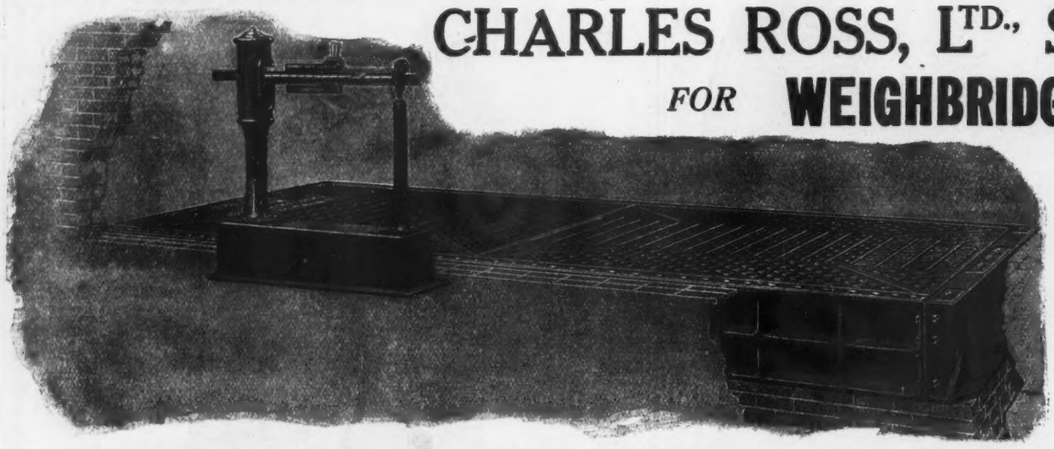

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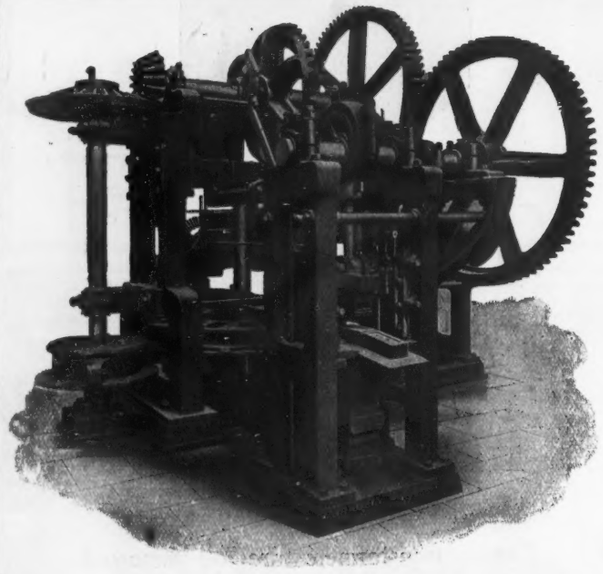

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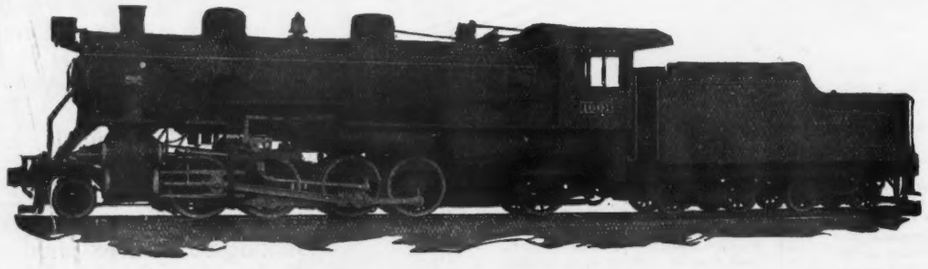

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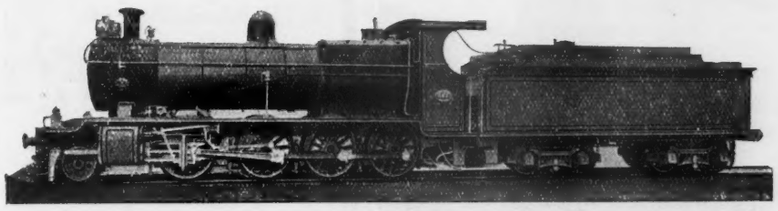

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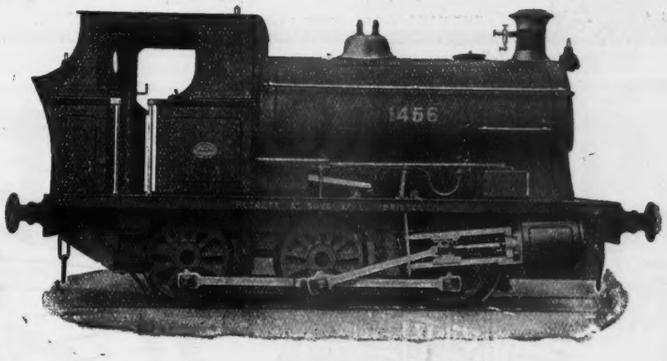

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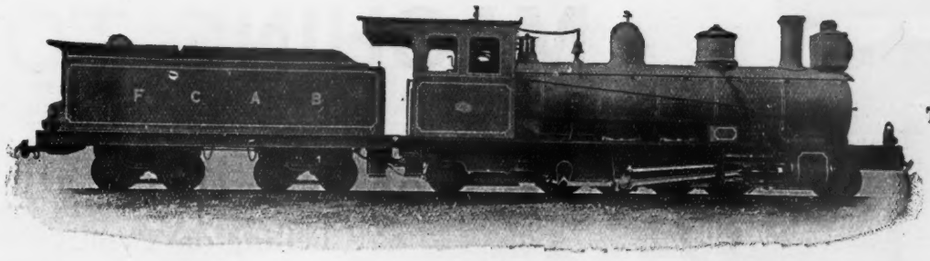

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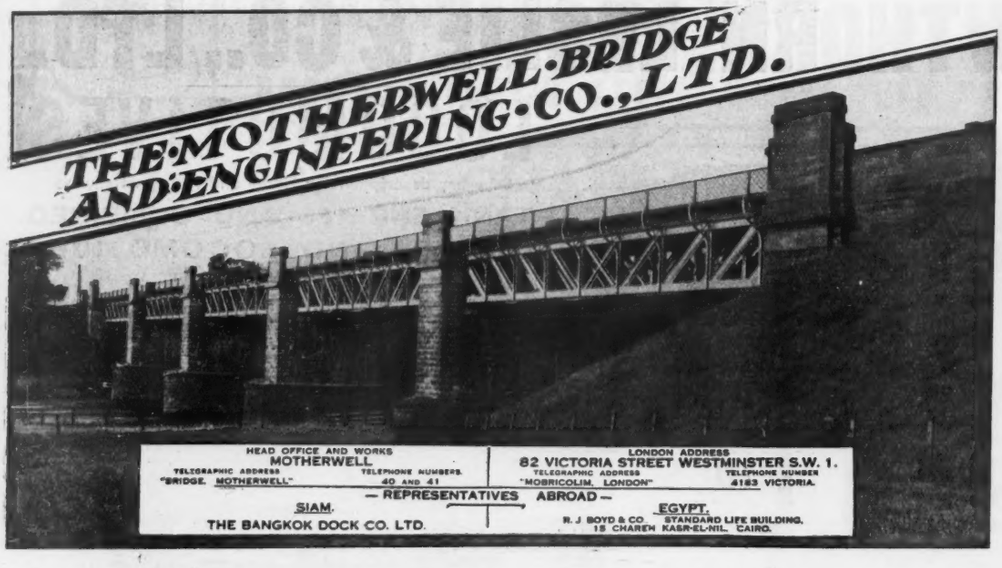
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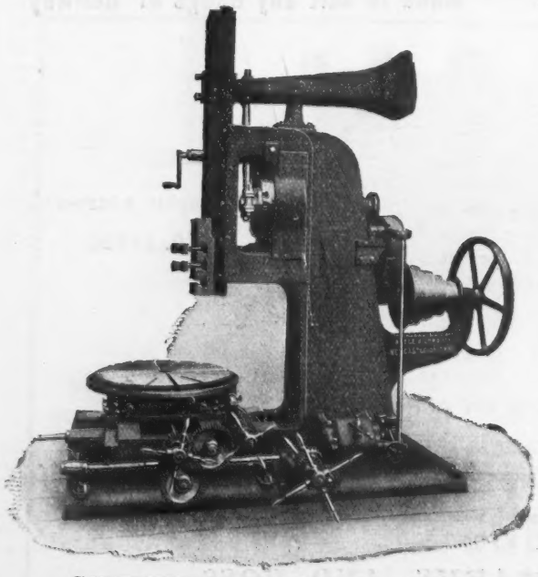

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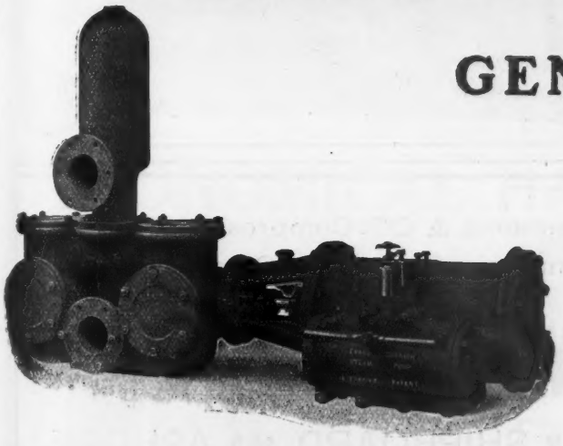

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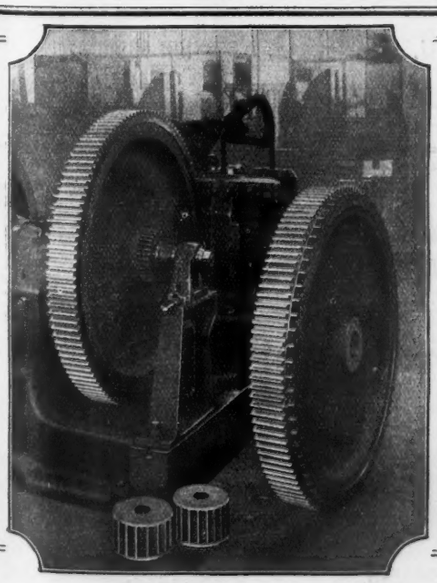

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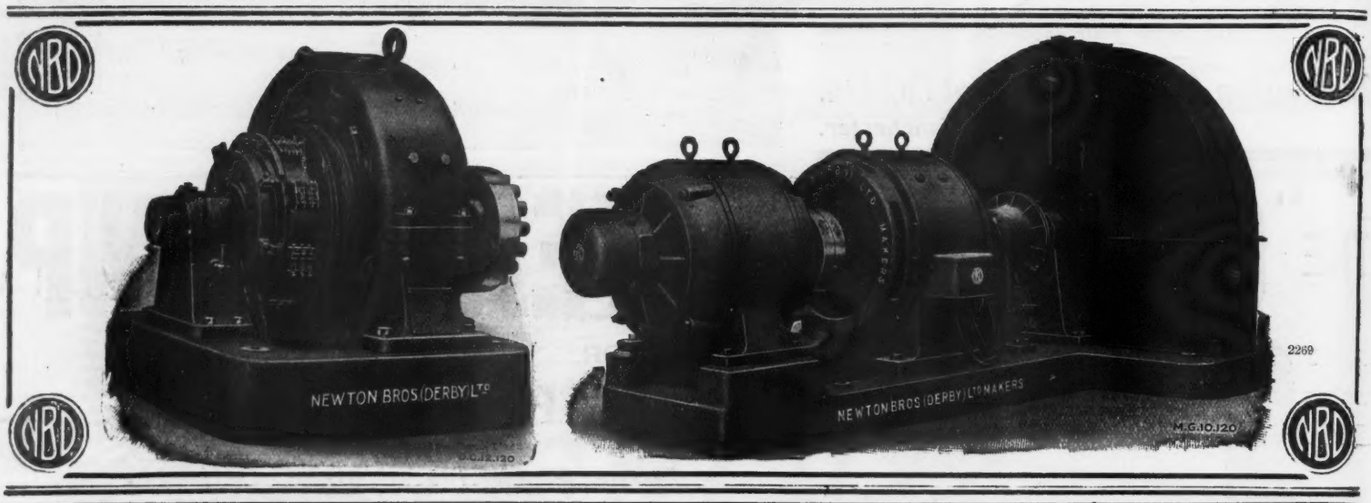

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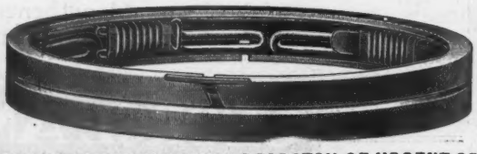

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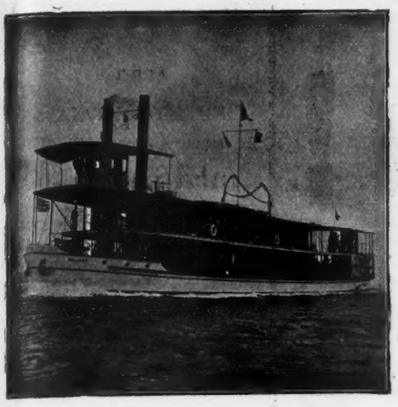

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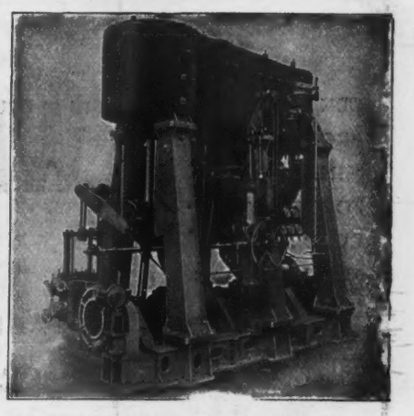

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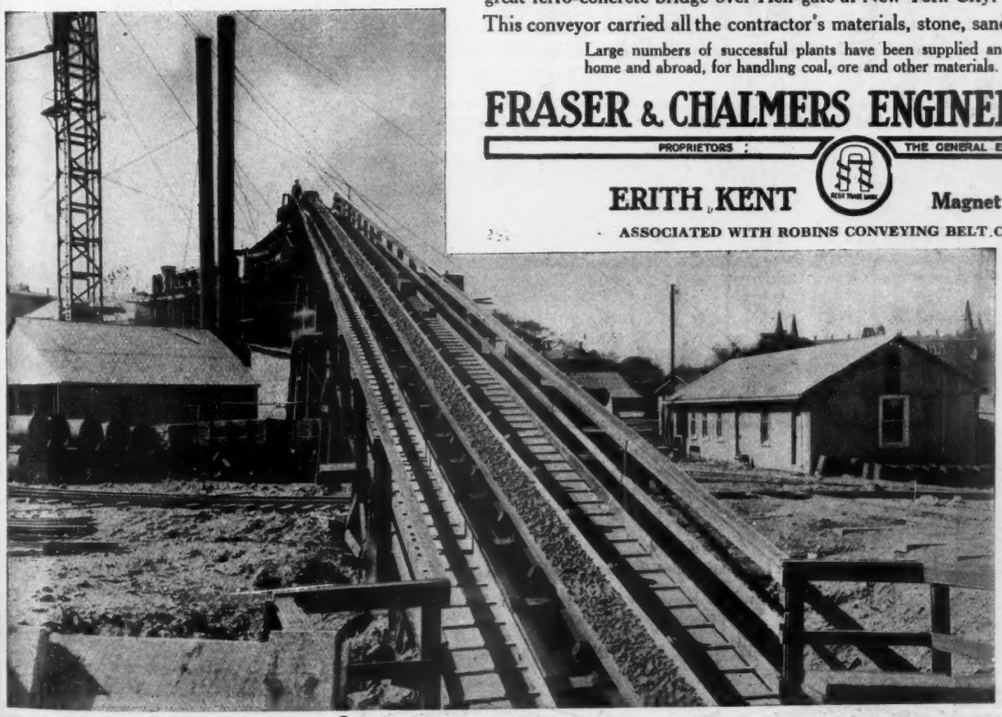

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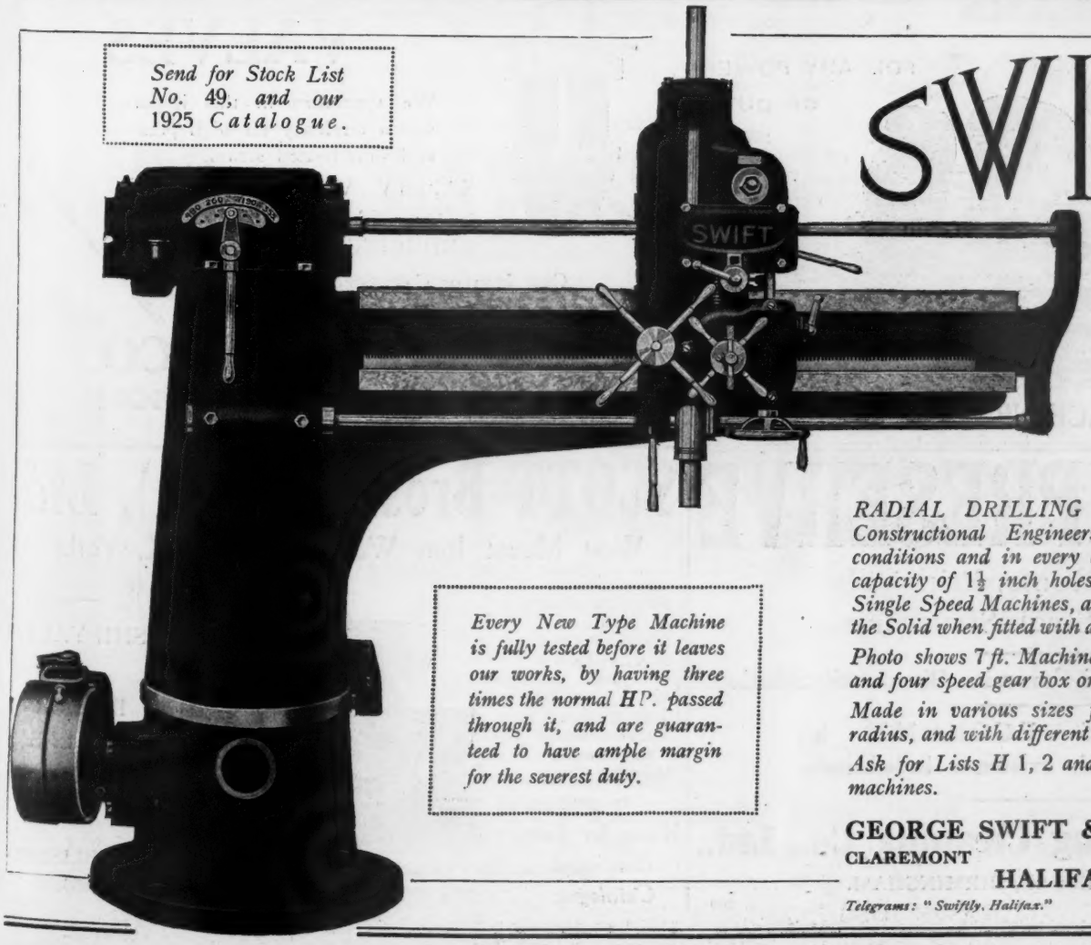

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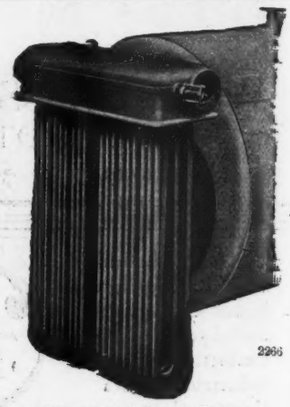

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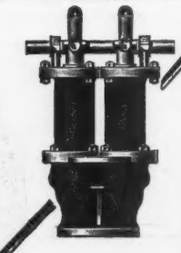

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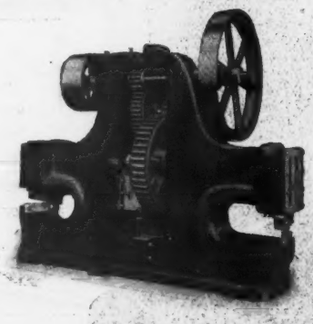

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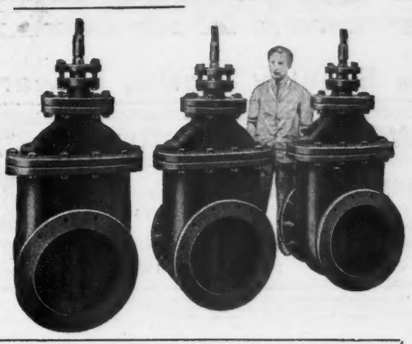

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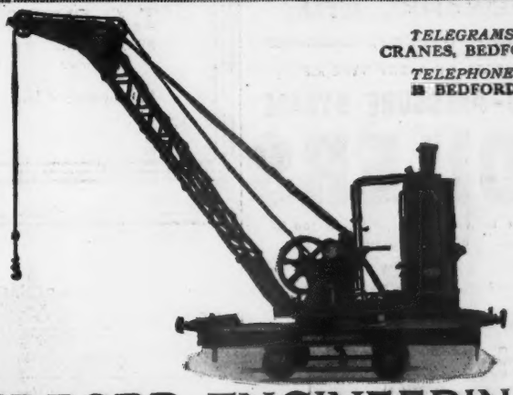

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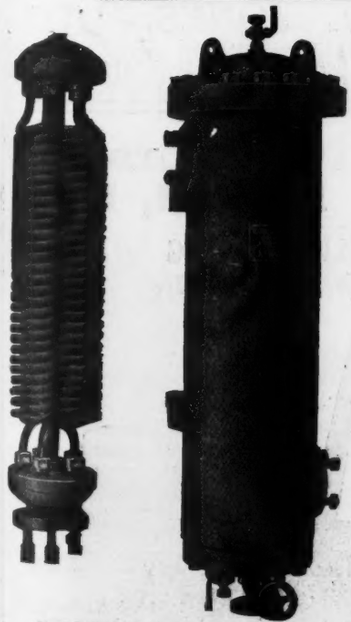

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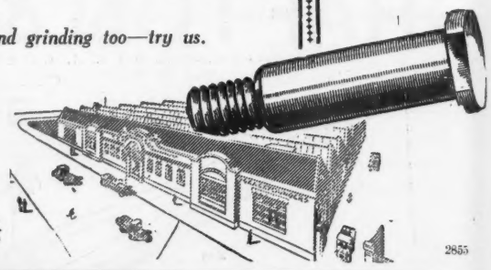

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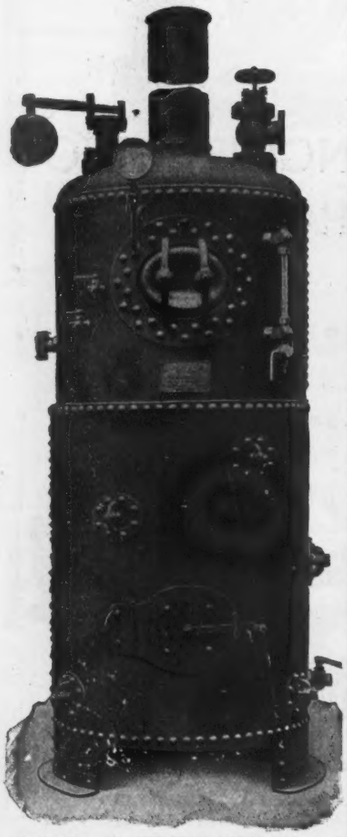

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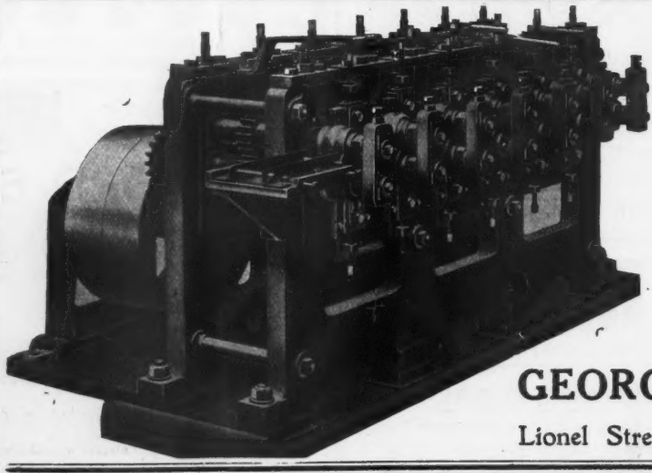

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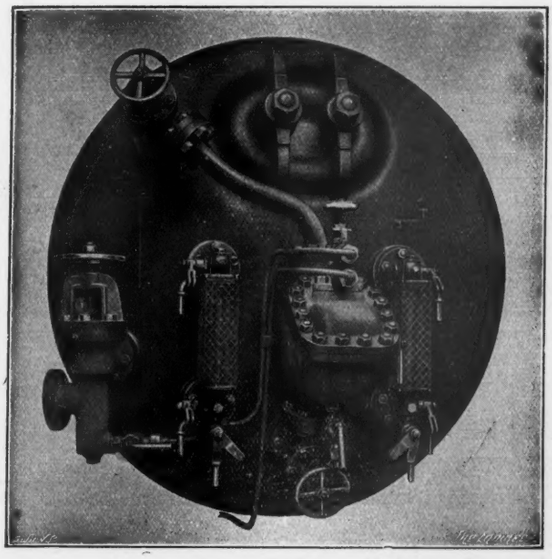

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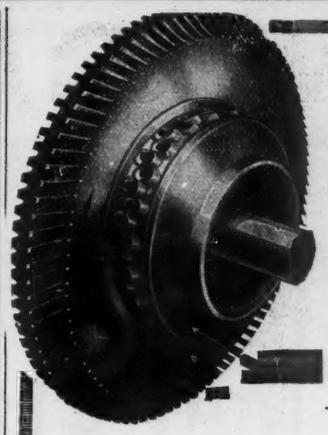

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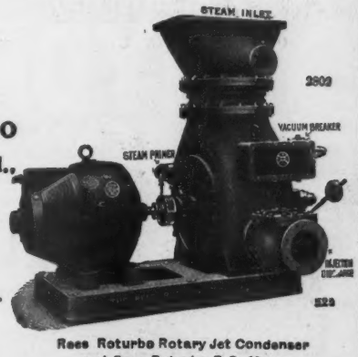

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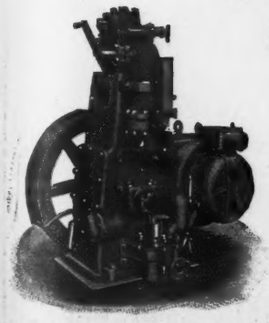

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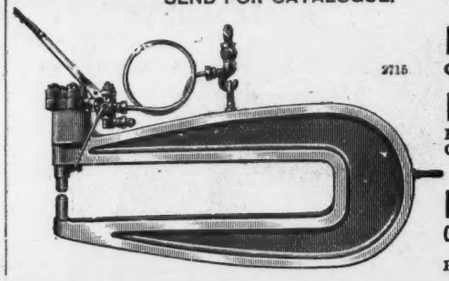

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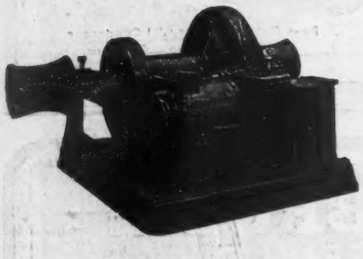

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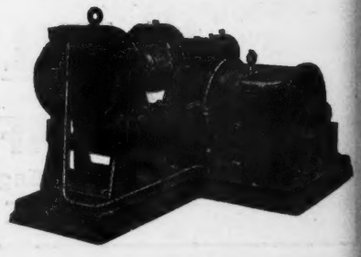

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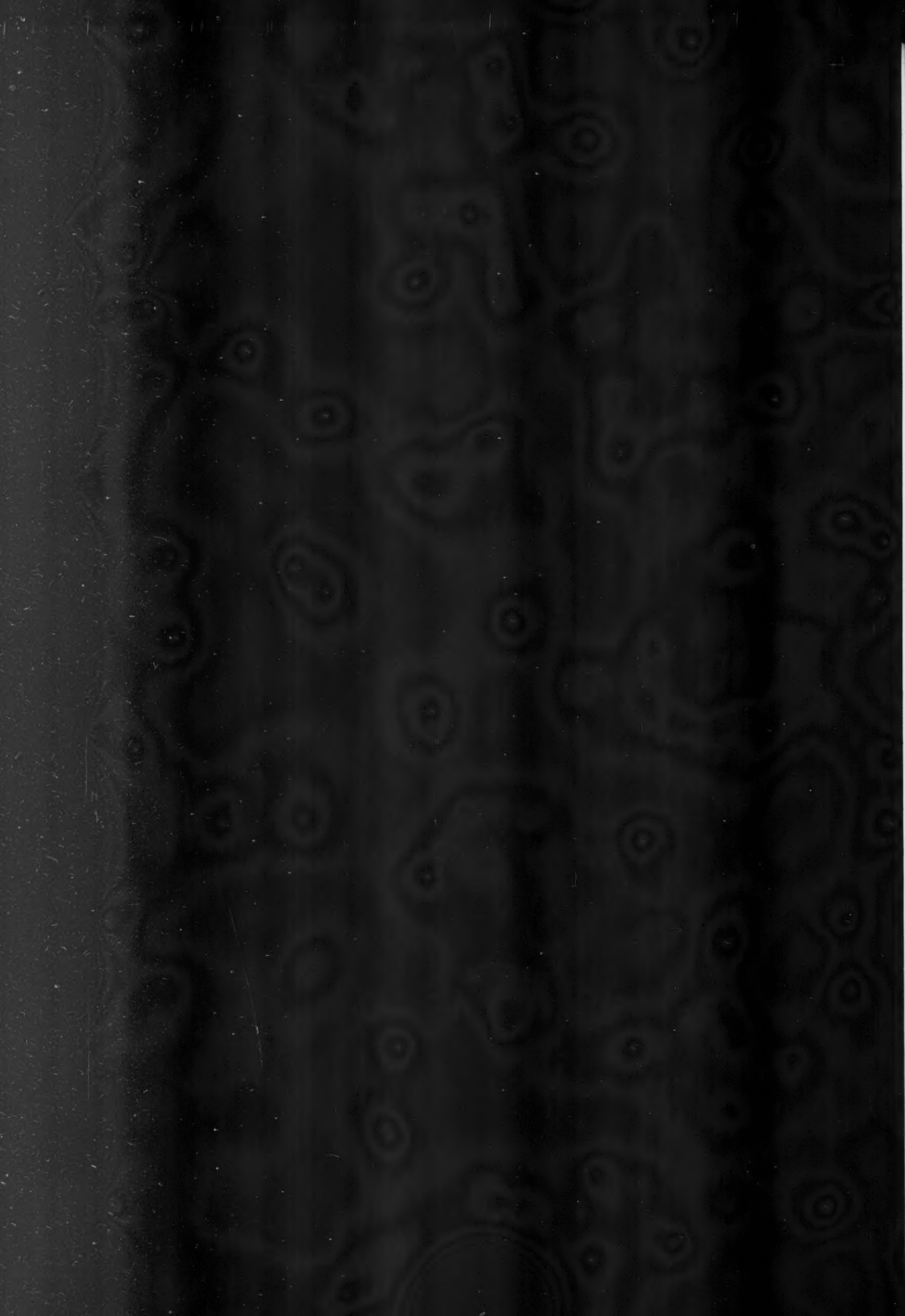

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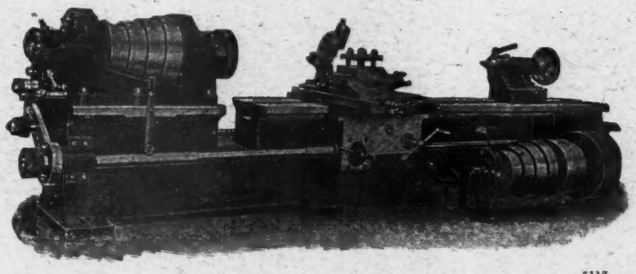
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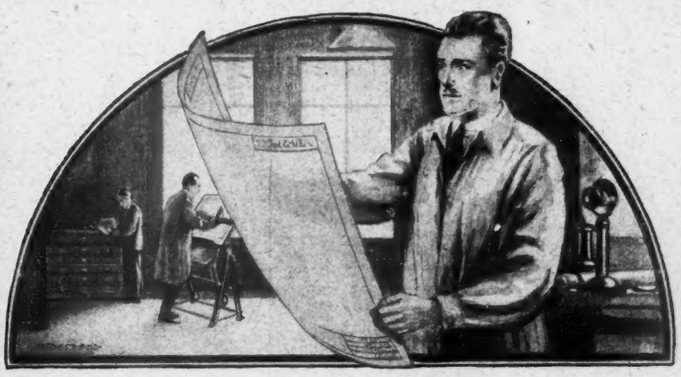
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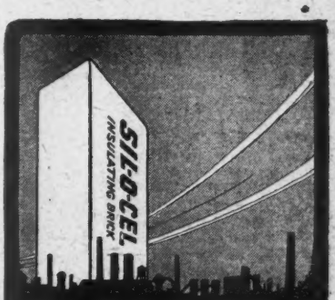

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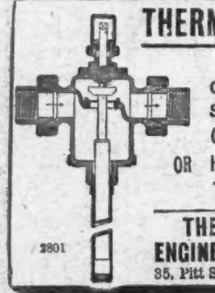
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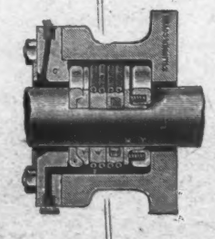
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105, York Street, LEEDS. 2721 *'Phone:* 21639 *Tels.:* "Scriven, Leeds."

"Asquith" Drills Pay.
Ask the User! 2847
Special Deliveries on many sizes.
Radials 5 ft. to 12 ft.; Verticals up to 5 ft. Various size Horizontals.
Wm. ASQUITH (1920), Ld., Park Works, Halifax. || *See Displayed Advt. June 19.*

The Turbine Furnace burns LOW GRADE FUELS Economically & Efficiently.
Installed under Strict Guarantee.
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EUREKA GAUGE GLASS
ESTABLISHED 1852
ASTON, BIRMINGHAM. 1497

MACHINE CUT
GEARS
Spurs, Bevels, Spiral, Worm, and Worm Wheels.
HIGHFIELD GEAR CUTTING CO.
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IRON & STEEL
TUBES
POLES, STEAM MAINS, TUBULAR PILES, &c.

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2095
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TELEGRAMS: BOXHAULING, SMITH, LONDON.
See Illustrated Advt. Last and Next Week.

A. BEEBEE, Studs, Bolts, Nuts, &c.
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Wrights
STEEL WIRE ROPES
For every Engineering Purpose
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Weighing from 3 to 50 tons, for any gauge of Highest-Class Workmanship and Materials. 1356
MAKERS OF
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FOR
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STEEL CASTINGS
STEEL AND IRON FORGINGS.
THE DARLINGTON FORGE LTD.,
DARLINGTON.
Tels.: "FORGE, DARLINGTON." Tel. 2610
2167 (See advertisement, page 72, June 19.)

GLENIFFER
MARINE MOTORS
See Illustrated Advt. page 21, June 5.
GLENIFFER MOTORS, LTD.,
Anniesland, GLASGOW. 2096

ENTWISLE & CASS, LD.
Engineers, BOLTON.
For CENTRIFUGAL PUMPS
AIR COMPRESSORS,
CLUTCHES, GEARING.
CASTINGS up to 10 TONS.
BLEACHING, DYEING & PRINTING
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BERTRAMS LIMITED
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THOS. SUDRON & Co., Ltd.,
STOCKTON-ON-TEES.
MAKERS OF MARINE AND
VERTICAL TYPE BOILERS. SHIPS
MASTS. TANKS. MOORING BUOYS,
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MICHELL BEARINGS, LD.,
ENGINEERS and MANUFACTURERS of
Michell Thrust & Journal Bearings.
London Office: 2456
3, Central Buildings, Westminster.
See large Advertisement, page 62, June 5.

The CLYDE STRUCTURAL IRON CO., Ltd.,
Clydeside Ironworks, Scotstoun, Glasgow.
MANUFACTURERS OF
Iron & Steel Roofs, Buildings,
Workshops, &c., &c.
London Agents: GILLESPIE & Co., LTD., Leadenhall Buildings, 1, Leadenhall Street, E.C. 3. 2601

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THE DAYS OF TIGHT BELTS ARE OVER.
enables belts to run slack without *slip*.
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FERGUSON BROS. (PORT GLASGOW) Ld.
PORT GLASGOW,
ENGINEERS AND SHIPBUILDERS.
See Last and Next Week's Half-page Illustrated Advertisement. 2604

IRON CASTINGS
of every description.
THE SEAHAM FOUNDRY CO. LTD.
Seaham Harbour,
CO. DURHAM,
Telephone: 71 Seaham. 2011

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PNEUMATIC
EJECTORS
For RAISING SEWAGE, SLUDGE, PAIL CONTENTS, &c.
AS USED AT
RANGOON, KARACHI, BOMBAY, EASTBOURNE, NORWICH, GOSPORT, HOUSES OF PARLIAMENT, Westminster, and many other places.
AIR COMPRESSING MACHINERY 2911
COMPRESSED AIR LIFTS For Raising Water from Wells, Boreholes, &c.
For Pamphlets and full particulars apply to the Manufacturers—
HUGHES & LANCASTER, Ld., 16, Victoria St., LONDON, S.W.

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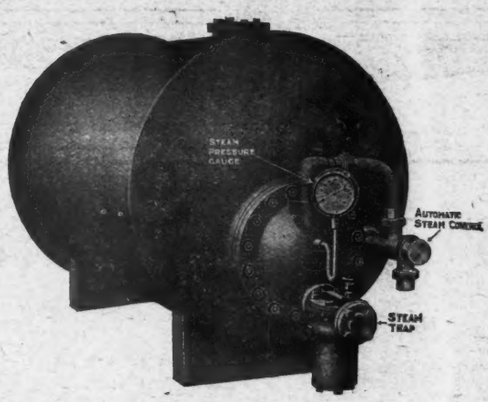
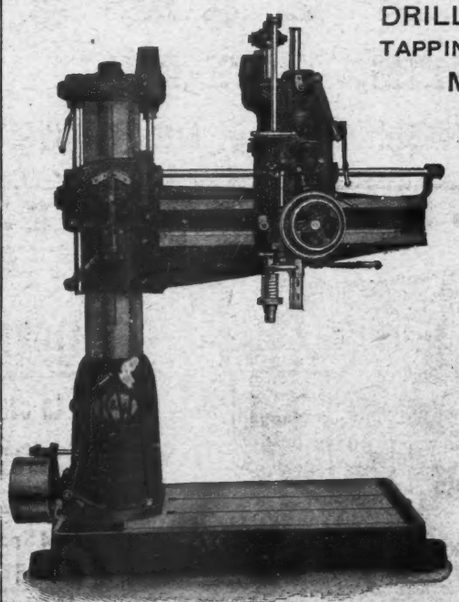


SEND YOUR ENQUIRIES
FOR:— CALORIFIERS OF ANY SIZE FOR ANY PURPOSE; FOR USE WITH EITHER LIVE OR EXHAUST STEAM
TO:—
WRIGHT'S FORGE & ENGINEERING Co., LD.
'PHONE—32 Tipton. 6585 London Wall.
TIPTON, Staffs. AND 57, Bishopsgate, LONDON, E.C. 08753
WIRE—Forgings, Tipton. Penetration, Stock, London.

DRILLING & BORING SPECIALISTS.

DRILLING, BORING, TAPPING & STUDDING MACHINES.
From 3' 0" radius upwards. (4' Illustrated).
Made with low base or box bed.
Additional Tapping Spindle Model.
WORKING CAPACITIES.
CAST IRON, from solid ... ... 2"
STEEL, from solid 1¼"
BORING ... ... 6"
TAPPING, With. ... 2"
We make a full range of machines for various duties.
Send for Catalogue.
2604
Telephone: 1673 Halifax. Telegrams: KAW Halifax. Code: Marconi International.
KITCHEN & WADE, HALIFAX, ENGLAND.

BULL'S METAL & MELLOID CO.
HEAD OFFICE AND WORKS: LIMITED.
YOKER, Near GLASGOW.
TELEGRAMS: "MELLOID, YOKER."
BULL'S METAL.—Propellers, Bars, Sheets, Pump Rods, Valve Spindles, Condenser Stays & Plates, &c.
MELLOID. (Reg. Trade Mark and Patented.)—Condenser Tubes, Plates and Stays, Boiler Tubes, Stays and Plates, Fire-box Plates, Bars, Sheets, Valves, &c.
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BARRY, HENRY & COOK, LTD.
Shafting, Gearing, Pulleys, Clutches, etc.
West North Street, ABERDEEN.

ELECTRO-MAGNETIC CHUCKS
FOR ACCURATE GRINDING.
RAPID MAGNETTING MACHINE CO., Ltd.,
CRESCENT BIRMINGHAM. 09626

The MACFARLANE ENGINEERING CO., LTD.
Netherlee Road, Cathcart.
DYNAMOS and MOTORS
See Monthly Advert., June 19. 2589

LOCOMOTIVES
FROM STOCK.
ALL GAUGES AND SIZES. 1605
KERR STUART'S
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BELLISS & MORCOM
BIRMINGHAM. LTD.
Self-lubricating Steam Engines, Turbines Air & Gas Compressors, Condensing Plants, Heavy Oil Engines, Paraffin Engines, Pneumatic Hose Couplings.
See Illustrated Advt., page 60, June 19. 2632

H. & T. DANKS (NETHERTON) LTD.
NETHERTON, DUDLEY, WORCS.

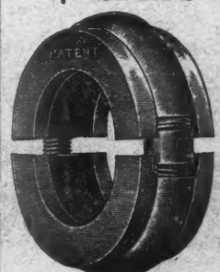
Cornish Boilers

Lancashire Boilers
2249

MECHANS LIMITED,
Engineers & Contractors,
SCOTSTOUN IRONWORKS, GLASGOW;
LONDON OFFICE:
10, Princes Street, Westminster, S.W.1.
See Illustrated Advertisement appearing June 19 and July 17. 1734

MAXWELL & FAGE,
(Successors to BRUCK & STILL, LTD.)
49, Sefton Street, LIVERPOOL.
CONSTRUCTIONAL ENGINEERS & CONTRACTORS for Steel Buildings, Bridges, Girders, and all descriptions of Structural Work. Timber Buildings designed for use at home & abroad.
See Illustrated Advert. Preceding & Following Weeks.
Catalogues, Designs & Estimates on application. 2332
Tels: No. 1817 Royal. Telegrams: "Galvaniser," Liverpool.

BOLTS and NUTS
of
EVERY KIND.
Kirby Banks Screw Co., Ltd.,
Beeston, Leeds. 2826

TRIER'S PATENT
"SPLIT GRIP"
COLLAR


As useful as a split pulley.
MADE IN HALVES
No set screw to Cause Accidents.
GRIPS LIKE A VICE.
Fixed or removed without Disturbance.
Sole Makers—
TRIER Bros. Ltd.,
36, Victoria St., Westminster, S.W.1

8000 tons of coal saved by one Green's Economiser

E. GREEN & SON Ltd., are now replacing in France a Green's Economiser that has been working for 44 years. At an average estimate this Economiser must have saved the owners 8000 tons of coal.

With a Green's Economiser 15—20% less coal is burned in boiler plants.

Book'e's. Estimates.

Interviews on request.

1925

E. GREEN & SON LTD., WAKEFIELD - ENGLAND.

'Phone: 443 (3 lines).
'Grams: "Economiser."

CRANES OF ALL TYPES

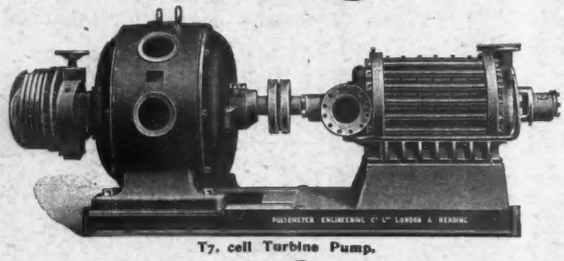
GEORGE RUSSELL & Co LIMITED
MOTHERWELL
NEAR GLASGOW

2569

High Efficiency

Centrifugal and Turbine Pumps

For all Lifts up to 3000 Feet.



T7. cell Turbine Pump.

Our pumps are made in such a variety of types and sizes that we can usually offer one to meet exactly any specified duty. Our lists give full information as to the quantity thrown on various lifts and the horse power required for that quantity.

Write for List No. 885.

2608

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Pulsometer Engineering Co. Ltd

Nine Elms Works, READING.

BRIGHT COMPRESSED

SHAFTING

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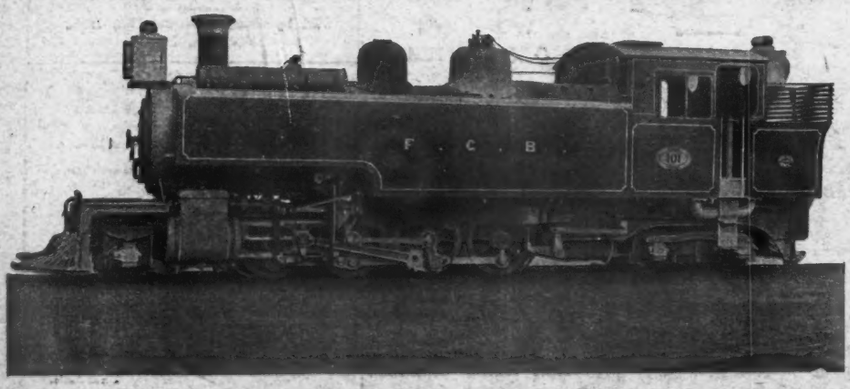
ROUNDS. HEXAGONS. FLATS. SQUARES.

KIRKSTALL FORGE LTD., NEAR LEEDS.

THE HUNSLET ENGINE CO., LEEDS. LTD.



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LOCOMOTIVE ENGINES

Adapted to every variety of work and gauge.

Also Manufacturers and Proprietors of

THE SEABORNE INTERCEPTOR

for Screw and Centrifugal Pumps.

Designs and Specifications supplied or worked to

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TELEGRAPHIC ADDRESS:—"ENGINE, LEEDS."
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